23rd Annual National Test & Evaluation Conference

"Test & Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems"

Hilton Head Island, SC

12 - 15 March 2007

Agenda

MONDAY, MARCH 12, 2007

TUTORIALS - SESSIONS T1 - T5

- Tutorial T1. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives - Mr. Jeffrey Manthos, Program Analyst, GSA
- Tutorial T2. The Critical Link Between Test & Evaluation and Modeling & Simulation - Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates
- Tutorial T4. DoD Acquisition Policy on Suitability KPP and Related Issues - Dr. Paul, Alfieri, Director of Research, DAU

TUTORIALS: Sessions T5 - T8 (Continued Sessions)

- Tutorial T5. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives - Mr. Jeffrey Manthos, Program Analyst, GSA
- Tutorial T6. The Critical Link Between Test & Evaluation and Modeling & Simulation - Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates
- Tutorial T8. DoD Acquisition Policy on Suitability KPP and Related Issues - Dr. Paul Alfieri, Director of Research, DAU

TUESDAY, MARCH 13, 2007

Session A

- Conference Keynote Address: Assuring Quality and Sustainability in a Competitive Market - Mr. Keith E. Williams, President & CEO, Underwriters Laboratories

Session B

OTA's Roundtable: Military Perspectives on Testing for Sustainability and Life Cycle Costing
Chair: MG James Myles, USA, Commanding General ATEC
Panelist: RDML William McCarthy, USN, Commander OPTEVFOR
Mr. Jerry Kitchen, Commander AFOTEC
COL Michael Bohn, USMC, Commander MCOTEA

Session C

- Statistically-Based Test Optimization Strategies - Dr. Neal Mackertich, Raytheon Integrated Defense Systems
- Report from the NDIA Industrial Committee on Operational Test & Evaluation (ICOTE) - Mr. Larry Graviss, Vice President, Jacobs Technology, Inc.

Concurrent Focus Sessions

Session D

Planning & Implementing Systems Engineering/T&E to Address Sustainability

- FS D1.1 T&E for Verifying Technology Development and Maturation - Mr. Chris DiPetto, Deputy Director for DT&E, OUSD (AT&L)/SSE
- FS D1.3 Using Technology Readiness Assessments (TRA's) to Assess the Maturity of Life Cycle Related Technologies - Dr. Jay Mandelbaum, IDA
- FS D1.4 Results of FY 2006 Test Resources Management Center Range Encroachment Survey Provided to the August 2006 TRMC Infrastructure Review - Mr. William Egan, IDA
- FS D1.5 Test and Training Enabling Architecture, Use to Prototype Joint Mission Environment Test Capability (JMETC) - Mr. Richard Lockhart, Defense Test Resource Management Center
- FS D1.6 TRACER: A Tradespace Analysis Framework - Mr. Gerry Belcher, LMI

Reducing Total Cost of Ownership & Realistic Estimates of Reliability

- FS D2.1 Low Cost Epoch-by-Epoch Network Centric Positioning Unit (ENPU) for FCS Testing - Dr. Jeffrey Fayman, Geodetics, Inc. and Dr. Lydia Bock, Geodetics, Inc.
- FS D2.2 Testing of the GPS SAASM End-to-End Functionality on Operational Weapon Systems Without the Availability of Signal in Space - Mr. Jim Killian, 46 Test Squadron, Holloman AFB
- FS D2.4 A Successfully Implemented Coordinated Subsystem Reliability Growth Planning Approach- Mr. Louis Chenard, Bombardier & Mr. Paul Ellner, AMSAA
- FS D2.5 Understanding the Combined Influence on Ownership Cost of Reliability, Maintainability, Component Packaging, Commonality, and Process Performance - Dr. James A. Forbes, LMI
- FS D2.6 Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning - Mr. James Carpenter, AVW Technologies

Test Technology

- FS D3.1 Hazard Assessment of the SM-3 Block IA Missile - Mr. William Houchins, NSWC Dahlgren
- FS D3.2 The Four Element Framework: An Integrated Test & Evaluation Strategy - Mr. Christopher Wilcox, ATEC, APG
- FS D3.3 Operability Testing for High Availability Systems - Mr. Edward Beck, CSC
- FS D3.5 746 Test Squadron Testing of the Latest Embedded GPS/INS (EGI) Hybrid
- Navigation System for the F-16 Fighting Falcon - Mr. Jim Killian, 46 Test Squadron, Holloman AFB
- FS D3.6 Qualification Testing of the EFSS 120mm Mortar Ammunition - Mr. Patrick Freemyers, NSWC Dahlgren
- FS D3.7 Operational Analysis of Modern Condition Based Maintenance (CBM) to Enhance System Sustainability - Dr. Don Gaver, NPS

WEDNESDAY, MARCH 14, 2007

Session E

- Advancing Survivability - Mr. Regis Luther, Armor Holdings
- A Concept for Suitability Assessment in Capabilities-Based T&E - Dr. Vincent P. Roske, Institute for Defense Analyses

Session F

- Development, Test & Evaluation of Unmanned Ground Vehicles/Robots, VADM Joseph Dyer, USN (Ret), President and General Manager, iRobot Corporation
- Industry Panel:
  - Sustainability KPP: Industry Weighs in on Bidding for It and Building for It - Mr. Steve Zink (For Mr. John Stoddart)
  - Past, Present & Future Trends in RM&A - Mr. Ron Mutzelburg, Vice President, Boeing Phantom Works, DC

Session G

- Coping with Reliability, Sustainability and Life Cycle Costs at DHS - Dr. George Zarur, Science Advisor, Science and Technology, DHS
- DT&E Panel: Systems Engineering and DT&E for System Sustainability
Chair: Col Richard Stuckey, USAF, Principal Assistant Deputy Director for DT&E, OUSD (AT&L)/SSE

Concurrent Focus Sessions

Session H

Test Methodology

- FS H4.1 Revisiting Quantitative Methods for Evaluating Training Programs for Systems Undergoing OT - Dr. Christopher Hekimian, SAIC
- FS H4.2 Producing Anywhere, Anytime Test, Evaluation and Diagnostics Capable Products to Eliminate the T&E Logistic Burden - Mr. Ryan Kinney, Agilent Technologies
- FS H4.3 Ship Suitability Testing - Preparing for the Future - Mr. Steve Fisher, NAVAIR, Patuxent River
- FS H4.4 Innovative Techniques to Solve Measurement and Detection Problems - Dr. Michael Slocum, Air Academy Associates

Test Planning

- FS H5.1 A Continuum of Testing for Military Systems - Dr. Patricia Jacobs, NPS
- FS H5.2 CTEC (Collaborative Test & Evaluation Capability) and the Event Streaming Media System - Mr. Reid Johnson, NUWC Keyport
- FS H5.3 Integrated Weapons System Testing - Ms. Laura DeSimone, NSWC Dahlgren
- FS H5.4 Estimating Durations and Trials to Success in Test Trial Programs - Dr. Danny Hughes, LMI
- FS H5.5 Operational Testing of Procedures is Critical to Effective Use/Integration of Emerging Capabilities: Report on Joint Space Control Operations - Col Christian Daehnick, USAF, Negation Joint Test & Evaluation

Technology to Reduce Life Cycle Cost

- FS H6.1 T&E of Electromagnetic Railguns - Mr. Thomas Boucher, NSWC Dahlgren
- FS H6.2 Cost Efficient Risk Management Through Integrated T&E Throughout the Systems Engineering Life-Cycle - Mr. Joseph Tribble, AVW Technologies
- FS H6.3 Sustainment of the Deployed Navy Munitions Inventory Through Continuous Quality Evaluation Test & Evaluation - Mr. Jeffrey Johnson, Navy Indianhead

THURSDAY, MARCH 15, 2007

Session I

- Suitability - At What Cost? - Dr. Paul Alfieri, DAU
  Service T&E Executives Speak
    - Mr. David Hamilton, Deputy Director, AF/TE
    - Mr. Steven Whitehead, OPTEVFOR
- The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability - Dr. Ernest Seglie, DOT&E
- Army T&E - Providing Essential Information to an Army at War - Mr. Brian Simmons, Army DTC

Session J

- Reliability-Based Design, Development and Sustainment - Dr. Anne Hillegas, Applied Research Associates
- Synthesis Panel**: Actions and Conference Takeaways

Panelists:

- Mr. Tom Wissink
- Ms. Diana Echols, Director of Customer Service Technology, Bell Helicopter Textron

23rd Annual National Test & Evaluation Conference

"Test & Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems"

Event # 7910
March 12–15, 2007

The Westin Resort
Hilton Head Island, SC

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Sponsored by the National Defense Industrial Association Test & Evaluation Division In Cooperation with the NDIA Systems Engineering and Logistics Divisions. The Conference is Supported by the Office of the Under Secretary of Defense (AT&L) and the Director, Operational Test & Evaluation (DOT&E)

Conference Announcement

Announcement

This National Test & Evaluation Conference is sponsored by NDIA's Test & Evaluation Division in conjunction with NDIA Systems Engineering and Logistics Divisions. The critical issues being addressed and the potential solutions to them impact not only the T&E community but also cut across the disciplines involved with the confluence of Systems Engineering and Logistics.

The ability of US combat forces to sustain their warfighting capability is being tested daily in the combat theaters of Iraq and Afghanistan. Some defense leaders contend that sustainment is only succeeding "on the backs of maintainers." At a previous NDIA event, a Service Secretary made clear that the nation's fighting forces face severe challenges and deserve the best a nation can offer. He identified several "shared values" fundamental to making resource allocation decisions. The first two, 1) Operational Suitability and 2) Sustainment of deployed systems are the focus of this Conference. The solutions to these issues lie at the intersection of Test & Evaluation, Logistics and Systems Engineering. While Operational Suitability is one of the two most common metrics assessed in DoD Test & Evaluation, Sustainment of Combat Operations and Equipment gets hardly a mention. Yet, its cost exceeds that of Pentagon procurement, and hence must be considered within the Test & Evaluation context as well.

Background

The Department of Defense is undertaking an initiative to make sustainability a key performance parameter of new systems. In part, the initiative is in recognition of the fact that between 65-80 percent of the total life cycle cost occurs after procurement. Currently the inventory is maintained by about 678,000 DoD personnel and at a cost of about $72 billion per year. The Sustainability Key Performance Parameter will require mandatory reporting on Materiel Availability, Materiel Reliability, and Ownership Cost. System designs to optimize these will require new and focused emphasis on sustainability during system engineering, and test and evaluation with recognition of how the sustainment system will operate when the system is fielded and deployed in a combatant environment.

Conference Objectives

- Discussion of T&E Metrics for Suitability and Sustainability (S&S)
- Reducing Total Ownership Costs and Role of T&E, SE and Logistics
- Test Planning to Assure Priority for Assessment of S&S
- Planning and Implementing Sustainability as a KKP Effectively
- Design Techniques Such as Condition-Based Maintenance and its T&E
- Test Methodology
- Testing for Realistic Estimates of Reliability
- Reducing Total Cost of Ownership
- Technologies to Reduce Life Cycle Cost
- Field Test Data and Archiving
- Feedback Sustainment Lessons to Improve Requirements, Programming T&E and Acquisition Process

NDIA Test & Evaluation Division

The Test & Evaluation Division was initially established under the auspices of the American Defense Preparedness Association (ADPA). With the merger of the National Security Industrial Association and the American Defense Preparedness Association on March 1, 1997, the T&E Division and its responsibilities were transferred to the National Defense Industrial Association. It is one of the 32 divisions of the Association.

NDIA TEST & EVALUATION DIVISION OBJECTIVES

NDIA's principal missions are to improve weapons technology, improve defense management, and maintain a strong science-industry-defense team continually responsive to all needs of the research, development, test & evaluation, production, logistics and management phase of national preparedness. It provides a forum for the exchange of ideas and information between its members and government agencies through a network of divisions, chapters, national and local meetings, and conferences and visits to the Department of Defense installations. Consistent with, and in furtherance of, the By-Laws and policies of the NDIA, the objectives of the T&E Division with respect to those government elements appropriate to its field of interest are:

Ensure the continuation, responsiveness, and where necessary, the revitalization of the industrial base to support our national security by:

• Maintaining effective liaison with the Department of Defense, Executive and Legislative Branches of the Government, and other governmental departments and agencies to apprise appropriate representatives of these organizations of T&E Division activities and keep abreast of current and future developments.

• Reviewing, evaluating, and providing recommendations with regard to government policies, practices, directives, and specifications including pending legislation concerning life cycle logistic support, supply chain integration, strategic and tactical mobility and business processes.

• Serving as a catalyst for community dialogue among T&E communities within government, industry and academia as well as provide an overarching means for dynamic interchanges of information with other functional areas.

• Sponsoring government/industry meetings, seminars and symposia to provide effective communications between government and industry relative to management activities for which the T&E Division is responsible under this matter.

• Maintaining viable liaison with other divisions of NDIA, other associations, and national-level industry coalitions for the purpose of exchanging information of mutual interest and coordinating and cooperating on activities requiring joint participation.

• Developing strategic directions effecting T&E partnerships between national security industries and government and to formulate proposals for national policies, addressing their impact on the national security industrial base.

• Establishing and maintaining a productive proactive dialogue with the national news media.

• Fostering learning of the basics and advanced concepts and techniques of T&E within the defense industry including the cross-pollination of commercial approaches to T&E for the defense community.

• Commemorating and recognizing services rendered by individuals, companies, and government agencies in meritorious acts related to activities enumerated above.

Monday, March 12, 2007

10:00 AM – 5:00 PM — Conference Registration

1:30 – 3:00 PM — CONFERENCE TUTORIALS

Tutorial Sessions are provided free of charge to all those registering for the Conference. Your attendance at these valuable tutorials is encouraged.

TUTORIALS: Sessions T1 – T4

- Tutorial T1. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives – *Mr. Jeffrey Manthos, Program Analyst, GSA*
- Tutorial T2. The Critical Link Between Test & Evaluation and Modeling & Simulation – *Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates*
- Tutorial T3. Reliability Growth Applied to Defense Issues– *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
- Tutorial T4. DoD Acquisition Policy on Suitability KPP and Related Issues – *Dr. Paul Alfieri, Director of Research, DAU*

3:00 – 3:15 PM — Tutorial Afternoon Break

3:15 – 5:00 PM — TUTORIALS: Sessions T5 – T8 (Continued Sessions)

- Tutorial T5. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives – *Mr. Jeffrey Manthos, Program Analyst, GSA*
- Tutorial T6. The Critical Link Between Test & Evaluation and Modeling & Simulation – *Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates*
- Tutorial T7. Reliability Growth Applied to Defense Issues– *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
- Tutorial T8. DoD Acquisition Policy on Suitability KPP and Related Issues – *Dr. Paul Alfieri, Director of Research, DAU*

5:00 – 6:30 PM — Evening Reception/Displays Open

6:30 PM — Display Area Closed for the Day

Your attention please: Survey sheets will be given to every conference registrant upon arrival. The survey sheets are intended to gather your thoughts and ideas regarding this NDIA T&E Conference. Registrants are requested to thoughtfully complete these surveys and return them to the NDIA desk prior to their departure. The results of these surveys will serve as a basis in planning for future conferences.

The Westin Resort, Hilton Head Island, SC

Tuesday, March 13, 2007

7:00 AM – 8:00 AM	Continental Breakfast in the Display Area
7:00 AM – 5:00 PM	Conference Registration

– Session A –

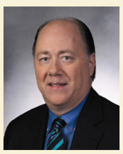
Session Chair: Mr. James O'Bryon

8:00 AM — Call to Order and Remarks – *Mr. Samuel Campagna, NDIA*

8:05 AM — Tribute to Our Nation, National Anthem

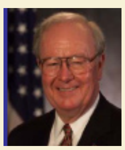
8:10 AM — Welcome and Conference Introductory Remarks– *Mr. James O'Bryon, Chairman, NDIA Test & Evaluation Division*

8:20 AM



Conference Keynote Address: Assuring Quality and Sustainability in a Competitive Market – *Mr. Keith E. Williams, President & CEO, Underwriters Laboratories*

8:55 AM



Government Keynote Address: Getting Our Arms Around Motivating and Testing for Sustainability – *Honorable Charles E. McQueary, Director, Operational Test & Evaluation, OSD*

9:30 AM

Military Perspectives Keynote Address: *Gen Larry D. Welch, USAF (Ret), President, IDA, Former Chief of Staff, USAF*

10:05 AM — Morning Break & Networking in the Display Area

– Session B –

Session Chair: Mr. James O'Bryon

10:35 AM — OTA's Roundtable: Military Perspectives on Testing for Sustainability and Life Cycle Costing

Chair: *MG James Myles, USA, Commanding General ATEC*

Panelist: *RDML William McCarthy, USN, Commander OPTEVFOR*
Maj Gen Robin Scott, USAF, Commander AFOTEC
COL Michael Bohn, USMC, Commander MCOTEA

12:15 PM — Luncheon

– Session C –

Session Chair: Dr. Mark Kiemele

1:30 PM — Statistically-Based Test Optimization Strategies – *Dr. Neal Mackertich, Raytheon Integrated Defense Systems*

2:10 PM — Report from the NDIA Industrial Committee on Operational Test & Evaluation (ICOTE) – *Mr. Larry Graviss, Vice President, Jacobs Technology, Inc.*

2:20 PM — Afternoon Break & Networking in the Displays Area

Tuesday, March 13, 2007 – Concurrent Focus Sessions

– Session D –

2:50 – 5:30 PM Planning & Implementing Systems Engineering/T&E to Address Sustainability

Focus Session D1

Session Chair: Dr. Anne Hillegas

FS D1.1 T&E for Verifying Technology Development and Maturation – *Mr. Chris DiPetto, Deputy Director for DT&E, OUSD (AT&L)/SSE*

FS D1.2 Early Application of Computer Program Systems Integration, Test and Performance Measurement – *Mr. Thomas Sobieralski, CSC*

FS D1.3 Using Technology Readiness Assessments (TRA's) to Assess the Maturity of Life Cycle Related Technologies – *Dr. Jay Mandelbaum, IDA*

FS D1.4 Results of FY 2006 Test Resources Management Center Range Encroachment Survey Provided to the August 2006 TRMC Infrastructure Review – *Mr. William Egan, IDA*

FS D1.5 Test and Training Enabling Architecture, Use to Prototype Joint Mission Environment Test Capability (JMETC) – *Mr. Gene Hudgins, BAE Systems*

FS D1.6 TRACER: A Tradespace Analysis Framework – *Mr. Jerry Belcher, ASARDA*

2:50 – 5:30 PM Reducing Total Cost of Ownership & Realistic Estimates of Reliability

Focus Session D2

Session Chair: Mr. Bill Yeakel

FS D2.1 Reduction of Total Ownership Costs (R-TOC) and Value Engineering – *Mr. David Erickson, USD (AT&L)*

FS D2.2 Testing of the GPS SAASM End-to-End Functionality on Operational Weapon Systems Without the Availability of Signal in Space – *Mr. Jim Killian, 46 Test Squadron, Holloman AFB*

FS D2.3 The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability– *Dr. Ernest Seglie, DOT&E*

FS D2.4 A Successfully Implemented Coordinated Subsystem Reliability Growth Planning Approach– *Mr. Louis Chenard, Bombardier*

FS D2.5 Understanding the Combined Influence on Ownership Cost of Reliability, Maintainability, Component Packaging, Commonality, and Process Performance – *Dr. James A. Forbes, LMI*

FS D2.6 Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning – *Mr. James Carpenter, AVW Technologies*

2:50 – 5:30 PM Test Technology

Focus Session D3

Session Chair: Mr. Dick Dickson

FS D3.1 Hazard Assessment of the SM-3 Block IA Missile – *Mr. William Houchins, NSWC Dahlgren*

FS D3.2 The Four Element Framework: An Integrated Test & Evaluation Strategy – *Mr. Christopher Wilcox, ATEC, APG*

FS D3.3 Operability Testing for High Availability Systems– *Mr. Edward Beck, CSC*

FS D3.4 Demonstrating Operational Suitability Data Merging During Developmental Tests: M&S vs. Raw Data, What is Needed? – *Mr. Jerome Perkins, SAIC*

FS D3.5 746 Test Squadron Testing of the Latest Embedded GPS/INS (EGI) Hybrid Navigation System for the F-16 Fighting Falcon – *Mr. Jim Killian, 46 Test Squadron, Holloman AFB*

FS D3.6 Qualification Testing of the EFSS 120mm Mortar Ammunition – *Mr. Patrick Freemyers, NSWC Dahlgren*

FS D3.7 Operational Analysis of Modern Condition Based Maintenance (CBM) to Enhance System Sustainability – *Dr. Don Gaver, NPS*

5:30 PM Afternoon Sessions Closes/Display Area Closes for the Day

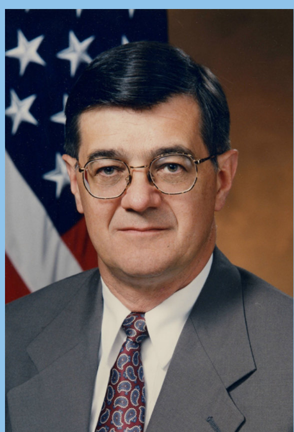
Tuesday, March 13, 2007 – Evening Activities

6:30 PM NDIA Honors Banquet

Presentation of the Walter W. Hollis Award for Lifetime Achievement in Test & Evaluation

This event is one of the highlights of our NDIA T&E Annual Conference. This year, we again take time to honor an individual who has demonstrated a lifetime commitment and contribution to the honest and realistic conduct of Test & Evaluation in support of the defense of the United States. This year, we are proud to honor such a person: Mr. James F. O'Bryon.

Guest of Honor – Mr. James F. O'Bryon



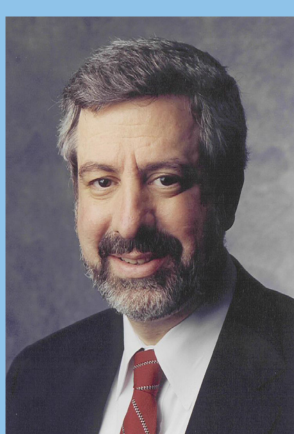
Mr. James O'Bryon's career began at IBM's R&D Center in NY while still in undergraduate school. Subsequent to this, he took a position in the Actuarial Department of New York Life. The Army drafted him in December 1964 and this moved him into the T&E world. He held RDT&E positions at the Aberdeen Proving Ground from 1965-1986. In 1986, he accepted the position as the first Director, Live Fire Testing in the Pentagon and retired from the Pentagon, November 2001 as Dep. Dir. OT&E/LFT&E, a Deputy Assistant Secretary of Defense position. Jim has an undergraduate math degree and graduate degrees from GWU in Ops Research and from MIT in Electrical Engineering.

Jim has chaired the NDIA T&E Division for 14 years and chaired dozens of national and international T&E Conferences. He has taught T&E at NDU, ICAF, NPS, University of Texas and other places for nearly 20 years, authored over 90 technical reports, and 80 open literature articles on T&E and related issues. He has just completed an 800 page book on Lessons Learned from Live Fire Testing and has testified before Congress on several occasions on T&E and Aviation Security. He has received the ADPA Gold Medal, the NDIA Gold Medal, the Arthur Stein Award for Excellence in Live Fire Testing and numerous DoD Awards including two personally presented by two different Secretaries of Defense. He now chairs a Committee of the National Academy of Sciences as well as serving as a consultant to several commercial and not-for-profit institutions.

Previous Recipients

2006: *RADM Bert Johnston, USN (Ret), Wyle Laboratories*
2005: *Hon Thomas Christie, DOT&E, OSD*
2004: *Dr. Marion L. Williams, Headquarters AFOTEC*
2003: *Mr. James W. Fasig, Aberdeen Test Center*
2002: *Mr. G. Thomas Castino, Underwriters Laboratories, Inc.*
2001: *Hon Philip E. Coyle, III, DOT&E, OSD*
2000: *Mr. Walter W. Hollis, Department of the Army*

Guest Speaker – Mr. Raymond Daddazio



It is also our special privilege to welcome as our guest speaker, Mr. Raymond Daddazio, President, Weidlinger Associates, New York, NY. September 11, 2001 is a day we will always remember and the scenes of the World Trade Center collapsing is forever etched in our minds.

Many were shocked not only by the aircraft attack against the buildings, but also shocked to see that these buildings collapsed from the attack, resulting in a huge loss of life and property. Weidlinger Associates was called upon to lead the efforts to assess what and how the WTC collapsed and also how to mitigate a repeat of such a failure if future attacks occur on other major structures. Mr. Daddazio will share with us his insights into their analysis and recommendations.

Note: Guests wishing to attend with registrants are welcome to attend this banquet. However, additional tickets must be purchased at the NDIA desk prior to the banquet.

Wednesday, March 14, 2007

7:00 AM–8:00 AM	Continental Breakfast in the Display Area
7:00 AM – 5:00 PM	Conference Registration

– Session E –
Session Chair: Mr. William Yeakel

8:00 AM	Call to Order and Remarks – *Mr. Samuel Campagna, NDIA*
8:05 AM	T&E Study Results– *GEN David Maddox, USA (Ret), Former Commander-in-Chief, US Forces Europe*
8:35 AM	Warfighting in a Climate Warming World: The Expectations, the Options, and the Solutions – *Hon Philip Coyle, III, Former Director, OT&E, OSD*
9:05 AM	Reliability Growth as Applied to Military Systems – *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
9:35 AM	Overcoming the Lowest Bidder with Quality Products in Government Purchases – *Mr. William Britz, President, Federal Program Management*
10:05 AM	Morning Break & Networking in the Display Area

– Session F –
Session Chair: Mr. Dick Dickson

10:35 AM	Development, Test & Evaluation of Unmanned Ground Vehicles/Robots, *VADM Joseph Dyer, USN (Ret), President and General Manager, iRobot Corporation*
11:05 AM	NDIA Update Snapshot – *MG Barry Bates, USA (Ret), Vice President, Operations, NDIA*
11:15 AM	Sustainability KPP: Industry Weighs in on Bidding for It and Building for It – *Mr. John Stoddart, President, Defense Business, Oshkosh Truck*

12:00 Noon Annual Awards Luncheon

The Tester of the Year Awards are presented annually to civilian and military personnel supporting all of the military services and OSD. For each military service and OSD, an award is presented to the outstanding defense civilian, outstanding military, and outstanding supporting contractor.

Note: Guests wishing to attend with registrants are welcome to attend this event. However, additional tickets must be purchased at the NDIA desk prior to the luncheon.

Wednesday, March 14, 2007

– Session G –
Session Chair: Mr. John Illgen

1:15 PM — Coping with Reliability, Sustainability, and Life Cycle Costs at DHS – *Dr. George Zarur, Science Advisor, Science and Technology, DHS*

1:45 PM — DT&E Panel: Systems Engineering and DT&E for System Sustainability

Chair: *Col Richard Stuckey, USAF, Principal Assistant Deputy Director for DT&E, OUSD (AT&L)/SSE*

Panelists: *Dr. David Jerome, Deputy Director of Air, Space and Information Operations, AF Materiel Command*
Mr. Brian Simmons, Deputy to the Commander/Technical Director, Army DTC
Mr. Richard Shubert, VP and Chief Engineering, Lockheed Martin Integrated Systems and Solutions
Mr. Ray Lytle, Director, Life Cycle Engineering, Raytheon Missile Systems

Wednesday, March 14, 2007 – Concurrent Focus Sessions

– Session H –

3:15 – 5:15 PM Test Methodology

Focus Session H4
Session Chair: Dr. Lowell Tonnessen

- FS H4.1 Revisiting Quantitative Methods for Evaluating Training Programs for Systems Undergoing OT – *Dr. Christopher Hekimian, SAIC*
- FS H4.2 Producing Anywhere, Anytime Test, Evaluation and Diagnostics Capable Products to Eliminate the T&E Logistic Burden – *Mr. Duane Lowenstein, Agilent Technologies*
- FS H4.3 Ship Suitability Testing – Preparing for the Future – *Mr. Ronald Harney, NAVAIR, Patuxent River*
- FS H4.4 Innovative Techniques to Solve Measurement and Detection Problems – *Dr. Michael Slocum, Air Academy Associates*

3:15 – 5:15 PM Test Planning

Focus Session H5
Session Chair: Mr. Dick Dickson

- FS H5.1 A Continuum of Testing for Military Systems – *Dr. Patricia Jacobs, NPS*
- FS H5.2 CTEC (Collaborative Test & Evaluation Capability) and the Event Streaming Media System – *Mr. Reid Johnson, NUWC Keyport*
- FS H5.3 Integrated Weapons System Testing – *Ms. Laura DeSimone, NSWC Dahlgren*
- FS H5.4 Estimating Durations and Trials to Success in Test Trial Programs – *Dr. Danny Hughes, LMI Government Consulting*
- FS H5.5 Operational Testing of Procedures is Critical to Effective Use/Integration of Emerging Capabilities:Report on Joint Space Control Operations – Mr. John Marrs, JT&E

3:15 – 5:15 PM Technology to Reduce Life Cycle Cost

Focus Session H6
Session Chair: Dr. Anne Hillegas

- FS H6.1 T&E of Electromagnetic Railguns – *Mr. Thomas Boucher, NSWC Dahlgren*
- FS H6.2 Cost Efficient Risk Management Through Integrated T&E Throughout the Systems Engineering Life-Cycle – *Mr. Joseph Tribble, AVW Technologies*
- FS H6.3 Sustainment of the Deployed Navy Munitions Inventory Through Continuous Quality Evaluation Test & Evaluation – *Mr. Jeffrey Johnson, Navy Indianhead*

5:15 PM — Display Area Closes for the Day

Thursday, March 15, 2007

7:00 AM – 8:00 AM	Continental Breakfast in the Display Area
7:00 AM – 5:00 PM	Conference Registration

– Session I –
Session Chair: Mr. John Illgen

8:00 AM	Call to Order and Remarks – *Mr. Samuel Campagna, NDIA*
8:05 AM	Suitability – At What Cost? – *Dr. Paul Alfieri, DAU*
8:10 AM	Service T&E Executives Speak Chair: *Mr. Walt Hollis, Former DUSA/OR* Panelists: *Mr. Dave Duma, Principal Deputy, DOT&E* *Dr. Hank Dubin, Army T&E* *Mr. Jack Manclark, AF/TE* *Mr. Steven Whitehead, OPTEVFOR*
9:05 AM	The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability – *Dr. Ernest Seglie, DOT&E*
9:30 AM	Army T&E – Providing Essential Information to an Army at War – *Mr. Brian Simmons, Army DTC*
10:00 AM	Morning Break & Networking in the Display Area (Last Opportunity to Visit Displays)

– Session J –
Session Chair: Mr. William Yeakel

10:20 AM	Reliability-Based Design, Development and Sustainment – *Dr. Anne Hillegas, Applied Research Associates*
11:15 AM	Synthesis Panel**: Actions and Conference Takeaways Chair: *Dr. Ernest Seglie, Science Advisor, DOT&E* Panelists: *Ms. Diana Echols, Director of Customer Service Technology, Bell Helicopter Textron* *Mr. Steven Whitehead, Technical Director, OPTEVFOR* *Mr. Stephen Daly, DDOT&E, Conventional Systems* *Mr. Chris DiPetto, Deputy Director for DT&E, OUSD (AT&L)/SSE*

**The discussion of this panel on the overall thrust of the Conference will serve as the basis of a White Paper and an overview article to be published in NDIA's *National Defense* Magazine.

11:55 AM	Conference Closing Remarks – *Mr. James O'Bryon, Chairman, NDIA Test & Evaluation Division*

Note: please be sure to return your completed survey forms to the NDIA registration desk

"The Department of Defense finds this event meets the minimum regulatory standards for attendance by DoD employees. This finding does not constitute a blanket approval or endorsement for attendance. Individual DoD component commands or organizations are responsible for approving attendance of its DoD employees based on mission requirements and DoD regulations."

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Hotel Information

The Westin Resort - Hilton Head Island
Two Grasslawn Avenue
Hilton Head Island, SC 29928
Phone : (843) 681-4000
Fax: (843) 681-1096

Please call the hotel directly to make your reservation. In order to ensure the discounted NDIA rate, make your reservations early and identify yourself as an attendee of the NDIA Test & Evaluation Conference. Rooms will not be held after February 19, 2007 and may sell out before then. Rates are also subject to increase after this date.

Government Rate*: $120.00
Industry Rate: $159.00

**or the prevailing government per diem rate at the time of the Conference. The government per diem rate is available only to active duty military and civilian government employees. ID will be required upon check-in. Retired military or government*

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Registration Information

	Early Before 1/29/07	Regular 1/29/07 - 2/26/07	Onsite after 2/26/07
Government/Allied/ Academia	$590	$650	$715
Industry NDIA Member	$690	$760	$835
Industry Non-NDIA Member	$730	$810	$890

To register online for this Conference, please visit the following link: http://www.ndia.org/meetings/7910. Online registration will close on February 26, 2007. You must register onsite after this date. You can also download the registration form from the NDIA website or complete the form contained in this brochure. Fax the completed form to (703) 522-1885 or mail to: Event #7910, National Defense Industrial Association, 2111 Wilson Boulevard, Suite 400, Arlington, VA 22201-3061. Please do not fax or mail registration forms after February 26 , 2007. You will need to register onsite after this date. Payment must be made at the time of registration. Registrations will not be taken over the phone.

CANCELLATIONS REMINDER: Cancellations received before January 29, 2007 will receive a full refund. Cancellations received from January 29, 2007 until February 26, 2007 will receive a refund minus a cancellation fee of $75.00. Refunds will NOT be given for cancellations received after February 26, 2007. Substitutions are welcome in lieu of cancellations.

Register Now! www.ndia.org/meetings/7910 - 11 -

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Conference Information

NDIA Tester of the Year Awards

The Annual NDIA Tester of the Year Awards will be presented during the Conference honoring those representatives from industry, government civilians and military personnel from the Army, Navy, Air Force, Marine Corps and OSD for outstanding achievement.

Displays

NDIA invites you to communicate your organizations capabilities at the 23rd Annual National Test & Evaluation Forum. An area will be available for the set-up of displays to demonstrate your company/organization's unique products and related capabilities. Displays will be tabletop or "pop-up" style. Allocated display space will be 10' wide by 6' deep. Pipe and drape will not be provided. The display registration form is available on the Conference website: www.ndia.org/meetings/7910. For additional information on displays, please contact Carissa Mirasol, Meeting Planner at cmirasol@ndia.org or (703) 247-2588. Cost to display: $1000.00. This fee includes one complimentary registration. Please refer to the Displayer Registration Form on page 15 of this brochure.

Promotional Partnership Opportunities

Increase your company or organization's exposure at this premier event by becoming a Conference Promotional Partner. A Promotional Partnership ($5,000) will add your company name/logo to the back cover of the onsite brochure as well as main platform recognition throughout the Conference, signage at all events including the opening reception and a 350-word organization description in the Conference agenda. Other Promotional Partnership levels are available. For more information, please contact Sam Campagna at (703) 247-2544 or via email at scampagna@ndia.org.

Identification Badges

During Conference Registration and check-in, each participant will be issued an identification badge. Please be prepared to present a picture ID. Badges must be worn at all Conference functions.

Conference Attire

Appropriate dress for this Conference is coat and tie for civilians and Class A uniform for military personnel.

Attendee Roster

An attendee roster will be distributed at the Conference. In order for your name to appear in the Conference attendee roster, you MUST register by February 26, 2007. There will be NO additional or updated versions.

Conference Proceedings

Proceedings will be available on the web through the Defense Technical Information Center (DTIC), and will be available two to three weeks after the Conference. You will receive notification via email that proceedings are posted and available on the web.

Conference Information

National Defense Magazine

Advertise in National Defense and increase your company's exposure at this Conference. National Defense will be distributed to attendees of this Conference as well as other NDIA events. For more information contact Dino Pignotti at (703) 247-2541 or via email at dpignotti@ndia.org.

Special Needs

NDIA supports the Americans with Disabilities Act of 1990. Attendees with special needs should call (703) 522-1820 and refer to the 23rd Annual National Test & Evaluation Conference, Event #7910, prior to February 26, 2007.

Inquiries?

For more information on the technical program, please contact the Conference Chairman, Mr. James O'Bryon at (443) 528-2711 or via email at jamesobryon@obryongroup.com.

For questions on the Conference, please visit the Conference website at www.ndia.org/meetings/7910 or contact Carissa Mirasol, Meeting Planner at (703) 247-2588 or via email at cmirasol@ndia.org.

Don't miss out on the upcoming
Live Fire Test &
Evaluation Conference
June 25-28, 2007

For more information, please visit:
www.ndia.org/meetings/7390

For inquiries, please contact Heather Horan, Meeting Planner at hhoran@ndia.org or at (703) 247-2570

23rd Annual National Test & Evaluation Conference
Westin Resort • Hilton Head Island, SC
March 12-15, 2007 • Event #7910

National Defense Industrial Association
2111 Wilson Boulevard, Suite 400
Arlington, VA 22201-3061
(703) 522-1820 • (703) 522-1885 fax
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3 Ways to sign up:
1. Online with a credit card at www.ndia.org
2. By fax with a credit card — Fax: 703-522-1885
3. By mail with a check or credit card

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By completing the following, you help us understand who is attending our meetings.

Primary Occupational Classification. *Check ONE.*
- ❑ A. Defense Business/Industry
- ❑ B. R&D/Laboratories
- ❑ C. Army
- ❑ D. Navy
- ❑ E. Air Force
- ❑ F. Marine Corps
- ❑ G. Coast Guard
- ❑ H. DOD/MOD Civilian
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- ❑ J. Trade/Professional Assn.
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Current Job/Title/Position. *Check ONE.*
- ❑ A. Senior Executive
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- ❑ C. Manager
- ❑ D. Engineer/Scientist
- ❑ E. Professor/Instructor/Librarian
- ❑ F. Ambassador/Attaché
- ❑ G. Legislator/Legislative Aide
- ❑ H. General/Admiral
- ❑ I. Colonel/Navy Captain
- ❑ J. Lieutenant Colonel/Commander/Major/Lieutenant Commander
- ❑ K. Captain/Lieutenant/Ensign
- ❑ L. Enlisted Military
- ❑ O. Other ____________

Year of birth ____________
(Optional)

Registration Fees

	Early *(Before 1/29/07)*	Regular *(From 1/29/07 - 2/26/07)*	**Late** *(After 2/26/07)*
Government/ Academia/Allied:	❑ $590	❑ $650	❑ $715
Industry NDIA Member:	❑ $690	❑ $760	❑ $835
Industry Non-NDIA Member:	❑ $730	❑ $810	❑ $890

Cancellations received before January 29, 2007 will receive a full refund. Cancellations received from January 29, 2007 to February 26, 2007 will receive a refund minus a cancellation fee of $75. No refunds for cancellations received after February 26, 2007. **Substitutions are welcome in lieu of cancellations!**

Payment Options
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Questions? Contact Meeting Planner, Carissa Mirasol
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Fax to: (703) 522-1885

23rd Annual National Test & Evaluation Forum
March 12-15, 2007
Westin Resort - Hilton Head Island • Hilton Head Island, SC
Registration for Displays - Event #7910

Name ____________________
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Company Name ____________________
Division/Dept. ____________________
Address ____________________
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Display Requirements:
All displays must be of the simple table-top/pop-up style standards. Space per display shall not exceed 10 ft. wide by 6 ft. deep. Minimal hardware to be utilized (computer systems for demonstrations are acceptable). No formal decorating company is involved. Companies must bring their own displays and plan to do their own set-up. Standard 2.5 x 6 ft. draped folding tables and chair will be provided for each display space. No other props or setups (pipe & drape, plants, etc.) will be utilized.

Display Hours:
Displays are to be set up by 4:00 PM March 12, 2007. Displays must be removed by 12:00 noon March 15, 2007.

Cost: Displays (includes complimentary registration for one displayer and electrical hook-up): $1000

Display Rules & Regulations:
1. If NDIA should be prevented from holding the conference for any reason beyond NDIA's control (such as, but not limited to, damage to the building, riots, strikes, acts of government, or acts of God) or if a displayer cannot occupy the assigned display space due to reasons beyond NDIA's control, then NDIA has the right to cancel the conference or any part thereof, with no further liability to the displayer other than a refund of display space fee, less a proportionate share of the conference cost incurred.
2. Neither the management of the host facility nor NDIA shall be liable for the damages, loss or destruction to the displays by reason of fire, theft, accident or other destructive causes. Displayer shall lease space at his sole risk. Neither the management of the host facility, NDIA nor any of their agents, servants or employees will be accountable or liable for accidents to displayers, their agents or employees.
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Deadline for sign-up is February 26, 2007. Make checks payable to NDIA - Event # 7910.

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STRENGTH THROUGH INDUSTRY & TECHNOLOGY

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23rd Annual National Test & Evaluation Conference

"Test & Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems"

Conference Agenda

Event # 7910
March 12-15, 2007

The Westin Resort
Hilton Head Island, SC

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Sponsored by the National Defense Industrial Association Test & Evaluation Division In Cooperation with the NDIA Systems Engineering and Logistics Divisions. The Conference is Supported by the Office of the Under Secretary of Defense (AT&L) and the Director, Operational Test & Evaluation (DOT&E)

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Conference Announcement

Announcement

This National Test & Evaluation Conference is sponsored by NDIA's Test & Evaluation Division in conjunction with NDIA Systems Engineering and Logistics Divisions. The critical issues being addressed and the potential solutions to them impact not only the T&E community but also cut across the disciplines involved with the confluence of Systems Engineering and Logistics.

The ability of US combat forces to sustain their warfighting capability is being tested daily in the combat theaters of Iraq and Afghanistan. Some defense leaders contend that sustainment is only succeeding "on the backs of maintainers." At a previous NDIA event, a Service Secretary made clear that the nation's fighting forces face severe challenges and deserve the best a nation can offer. He identified several "shared values" fundamental to making resource allocation decisions. The first two, 1) Operational Suitability and 2) Sustainment of deployed systems are the focus of this Conference. The solutions to these issues lie at the intersection of Test & Evaluation, Logistics and Systems Engineering. While Operational Suitability is one of the two most common metrics assessed in DoD Test & Evaluation, Sustainment of Combat Operations and Equipment gets hardly a mention. Yet, its cost exceeds that of Pentagon procurement, and hence must be considered within the Test & Evaluation context as well.

Background

The Department of Defense is undertaking an initiative to make sustainability a key performance parameter of new systems. In part, the initiative is in recognition of the fact that between 65-80 percent of the total life cycle cost occurs after procurement. Currently the inventory is maintained by about 678,000 DoD personnel and at a cost of about $72 billion per year. The Sustainability Key Performance Parameter will require mandatory reporting on Materiel Availability, Materiel Reliability, and Ownership Cost. System designs to optimize these will require new and focused emphasis on sustainability during system engineering, and test and evaluation with recognition of how the sustainment system will operate when the system is fielded and deployed in a combatant environment.

Conference Objectives

- Discussion of T&E Metrics for Suitability and Sustainability (S&S)
- Reducing Total Ownership Costs and Role of T&E, SE and Logistics
- Test Planning to Assure Priority for Assessment of S&S
- Planning and Implementing Sustainability as a KKP Effectively
- Design Techniques Such as Condition-Based Maintenance and its T&E
- Test Methodology
- Testing for Realistic Estimates of Reliability
- Reducing Total Cost of Ownership
- Technologies to Reduce Life Cycle Cost
- Field Test Data and Archiving
- Feedback Sustainment Lessons to Improve Requirements, Programming T&E and Acquisition Process

Following are members of the NDIA T&E Division Executive Committee

- Mr. Joe Andrese, *APG*
- Mr. Dennis Bely, *ARL*
- Dr. Keith Bradley, *LLNL*
- Mr. Britt Bray, *DRC Corporation*
- Dr. Paul Deitz, *HRED*
- Mr. Dick Dickson, *Tybrin Corporation*
- Mr. Russ Hauck, *Simulation Info Systems*
- Dr. Anne Hillegas, *ARA Corporation*
- Mr. John Illgen, *Northrop Grumman*
- RADM Bert Johnston, USN (Ret), *Wyle Labs*
- Dr. Mark Kiemele, *Air Academy Associates*
- Mr. Chuck Larson, *SURVICE Engineering*
- Mr. Jim O'Bryon, *The O'Bryon Group, T&E Division Chair*
- Dr. Ernest Seglie, *DOT&E*
- Mr. Jack Sheehan, *FCSCTO*
- Dr. Lowell Tonnessen, *IDA*
- Dr. Juan Vitali, *ATEC*
- Mr. Tom Wissink, *Lockheed Martin*
- Mr. Bill Yeakel, *ORSA Corporation*

NDIA Test & Evaluation Division

The Test & Evaluation Division was initially established under the auspices of the American Defense Preparedness Association (ADPA). With the merger of the National Security Industrial Association and the American Defense Preparedness Association on March 1, 1997, the T&E Division and its responsibilities were transferred to the National Defense Industrial Association. It is one of the 32 divisions of the Association.

NDIA TEST & EVALUATION DIVISION OBJECTIVES

NDIA's principal missions are to improve weapons technology, improve defense management, and maintain a strong science-industry-defense team continually responsive to all needs of the research, development, test & evaluation, production, logistics and management phase of national preparedness. It provides a forum for the exchange of ideas and information between its members and government agencies through a network of divisions, chapters, national and local meetings, and conferences and visits to the Department of Defense installations. Consistent with, and in furtherance of, the By-Laws and policies of the NDIA, the objectives of the T&E Division with respect to those government elements appropriate to its field of interest are:

Ensure the continuation, responsiveness, and where necessary, the revitalization of the industrial base to support our national security by:

- Maintaining effective liaison with the Department of Defense, Executive and Legislative Branches of the Government, and other governmental departments and agencies to apprise appropriate representatives of these organizations of T&E Division activities and keep abreast of current and future developments.

- Reviewing, evaluating and providing recommendations with regard to government policies, practices, directives and specifications including pending legislation concerning life cycle logistic support, supply chain integration, strategic and tactical mobility and business processes.

- Serving as a catalyst for community dialogue among T&E communities within government, industry and academia, as well as provide an overarching means for dynamic interchanges of information with other functional areas.

- Sponsoring government/industry meetings, seminars and symposia to provide effective communications between government and industry relative to management activities for which the T&E Division is responsible under this matter.

- Maintaining viable liaison with other divisions of NDIA, other associations and national-level industry coalitions for the purpose of exchanging information of mutual interest and coordinating and cooperating on activities requiring joint participation.

- Developing strategic directions effecting T&E partnerships between national security industries and government and to formulate proposals for national policies, addressing their impact on the national security industrial base.

- Establishing and maintaining a productive proactive dialogue with the national news media.

- Fostering learning of the basics and advanced concepts and techniques of T&E within the defense industry including the cross-pollination of commercial approaches to T&E for the defense community.

- Commemorating and recognizing services rendered by individuals, companies, and government agencies in meritorious acts related to activities enumerated above.

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Monday, March 12, 2007

10:00 AM – 5:00 PM — Conference Registration

1:30 – 3:00 PM — <u>CONFERENCE TUTORIALS</u>

Tutorial Sessions are provided free of charge to all those registered for the Conference. Your attendance at these valuable tutorials is encouraged.

<u>TUTORIALS: Sessions T1 – T4</u>

Archer East Ballroom	Tutorial T1. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives – *Mr. Jeffrey Manthos, Program Analyst, GSA*
Archer West Ballroom	Tutorial T2. The Critical Link Between Test & Evaluation and Modeling & Simulation – *Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates*
Danner East Ballroom	Tutorial T3. Reliability Growth Applied to Defense Issues – *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
Danner West Ballroom	Tutorial T4. DoD Acquisition Policy on Suitability KPP and Related Issues – *Dr. Paul Alfieri, Director of Research, DAU*

3:00 – 3:15 PM — Tutorial Afternoon Break

3:15 – 5:00 PM — <u>TUTORIALS: Sessions T5 – T8 (Continued Sessions)</u>

Archer East Ballroom	Tutorial T5. Innovative Acquisition Methodologies in Support of Test & Evaluation Objectives – *Mr. Jeffrey Manthos, Program Analyst, GSA*
Archer West Ballroom	Tutorial T6. The Critical Link Between Test & Evaluation and Modeling & Simulation – *Dr. Mark Kiemele, President and Co-Founder, Air Academy Associates*
Danner East Ballroom	Tutorial T7. Reliability Growth Applied to Defense Issues – *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
Danner West Ballroom	Tutorial T8. DoD Acquisition Policy on Suitability KPP and Related Issues – *Dr. Paul Alfieri, Director of Research, DAU*

5:00 – 6:30 PM — Evening Reception/Display Area Open

6:30 PM — Display Area Closed for the Day

<u>Your attention please:</u> Survey sheets will be given to every Conference registrant upon arrival. The survey sheets are intended to gather your thoughts and ideas regarding this NDIA T&E Conference. Registrants are requested to thoughtfully complete these surveys and return them to the NDIA desk prior to their departure. The results of these surveys will serve as a basis in planning for future conferences.

The Westin Resort, Hilton Head Island, SC

Tuesday, March 13, 2007

7:00 AM – 8:00 AM Continental Breakfast in the Display Area

7:00 AM – 5:00 PM Conference Registration

– Session A –
Session Chair: Mr. James O'Bryon

8:00 AM Call to Order and Remarks – *Mr. Sam Campagna, Director, Operations, NDIA*

8:05 AM Tribute to Our Nation, National Anthem – *Ms. Kera O'Bryon*

8:10 AM Welcome and Conference Introductory Remarks – *Mr. James O'Bryon, Chairman, NDIA Test & Evaluation Division*

8:20 AM

Conference Keynote Address: Assuring Quality and Sustainability in a Competitive Market – *Mr. Keith E. Williams, President & CEO, Underwriters Laboratories*

9:00 AM

Government Keynote Address: Getting Our Arms Around Motivating and Testing for Sustainability – *Honorable Charles E. McQueary, Director, Operational Test & Evaluation, OSD*

9:40 AM Keynoters' Dialogue – *Mr. Keith E. Williams, President & CEO, Underwriters Laboratories and Honorable Charles E. McQueary, Director, Operational Test & Evaluation, OSD*
*(**Audience may submit written questions to either speaker during this period.)*

10:05 AM Morning Break & Networking in the Display Area

– Session B –
Session Chair: Mr. James O'Bryon

10:35 AM OTA's Roundtable: Military Perspectives on Testing for Sustainability and Life Cycle Costing
Chair: *MG James Myles, USA, Commanding General ATEC*
Panelist: *RDML William McCarthy, USN, Commander OPTEVFOR*
Maj Gen Robin Scott, USAF, Commander AFOTEC
COL Michael Bohn, USMC, Commander MCOTEA

12:15 PM Luncheon

– Session C –
Session Chair: Dr. Mark Kiemele

1:30 PM Statistically-Based Test Optimization Strategies – *Dr. Neal Mackertich, Raytheon Integrated Defense Systems*

2:10 PM Report from the NDIA Industrial Committee on Operational Test & Evaluation (ICOTE) – *Mr. Larry Graviss, Vice President, Jacobs Technology, Inc.*

2:20 PM Afternoon Break & Networking in the Display Area

Tuesday, March 13, 2007 – Concurrent Focus Sessions

– Session D –

2:50 – 5:30 PM **Planning & Implementing Systems Engineering/T&E to Address Sustainability**

Focus Session D1

ARCHER EAST BALLROOM

Session Chair: Dr. Anne Hillegas

FS D1.1	T&E for Verifying Technology Development and Maturation – *Mr. Chris DiPetto, Deputy Director for DT&E, OUSD (AT&L)/SSE*
FS D1.2	Early Application of Computer Program Systems Integration, Test and Performance Measurement – *Mr. Thomas Sobieralski, CSC*
FS D1.3	Using Technology Readiness Assessments (TRA's) to Assess the Maturity of Life Cycle Related Technologies – *Dr. Jay Mandelbaum, IDA*
FS D1.4	Results of FY 2006 Test Resources Management Center Range Encroachment Survey Provided to the August 2006 TRMC Infrastructure Review – *Mr. William Egan, IDA*
FS D1.5	Test and Training Enabling Architecture, Use to Prototype Joint Mission Environment Test Capability (JMETC) – *Mr. Richard Lockhart, Defense Test Resource Management Center*
FS D1.6	TRACER: A Tradespace Analysis Framework – *Mr. Gerry Belcher, LMI*

2:50 – 5:30 PM **Reducing Total Cost of Ownership & Realistic Estimates of Reliability**

Focus Session D2

BARNWELL BALLROOM

Session Chair: Mr. Bill Yeakel

FS D2.1	Low Cost Epoch-by-Epoch Network Centric Positioning Unit (ENPU) for FCS Testing – *Dr. Jeffrey Fayman, Geodetics, Inc. and Dr. Lydia Bock, Geodetics, Inc.*
FS D2.2	Testing of the GPS SAASM End-to-End Functionality on Operational Weapon Systems Without the Availability of Signal in Space – *Mr. Jim Killian, 46 Test Squadron, Holloman AFB*
FS D2.3	The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability – *Dr. Ernest Seglie, DOT&E*
FS D2.4	A Successfully Implemented Coordinated Subsystem Reliability Growth Planning Approach– *Mr. Louis Chenard, Bombardier & Mr. Paul Ellner, AMSAA*
FS D2.5	Understanding the Combined Influence on Ownership Cost of Reliability, Maintainability, Component Packaging, Commonality, and Process Performance – *Dr. James A. Forbes, LMI*
FS D2.6	Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning – *Mr. James Carpenter, AVW Technologies*

2:50 – 5:30 PM **Test Technology**

Focus Session D3

ARCHER WEST BALLROOM

Session Chair: Mr. Dick Dickson

FS D3.1	Hazard Assessment of the SM-3 Block IA Missile – *Mr. William Houchins, NSWC Dahlgren*
FS D3.2	The Four Element Framework: An Integrated Test & Evaluation Strategy – *Mr. Christopher Wilcox, ATEC, APG*
FS D3.3	Operability Testing for High Availability Systems – *Mr. Edward Beck, CSC*
FS D3.4	Demonstrating Operational Suitability Data Merging During Developmental Tests: M&S vs. Raw Data, What is Needed? – *Mr. Jerome Perkins, SAIC*
FS D3.5	746 Test Squadron Testing of the Latest Embedded GPS/INS (EGI) Hybrid Navigation System for the F-16 Fighting Falcon – *Mr. Jim Killian, 46 Test Squadron, Holloman AFB*
FS D3.6	Qualification Testing of the EFSS 120mm Mortar Ammunition – *Mr. Patrick Freemyers, NSWC Dahlgren*
FS D3.7	Operational Analysis of Modern Condition Based Maintenance (CBM) to Enhance System Sustainability – *Dr. Don Gaver, NPS*

5:30 PM Afternoon Sessions Adjourn/Display Area Closed for the Day

Tuesday, March 13, 2007 – Evening Activities

6:30 PM NDIA Honors Banquet

Presentation of the Walter W. Hollis Award for Lifetime Achievement in Test & Evaluation

This event is one of the highlights of our NDIA T&E Annual Conference. This year, we again take time to honor an individual who has demonstrated a lifetime commitment and contribution to the honest and realistic conduct of Test & Evaluation in support of the defense of the United States. This year, we are proud to honor such a person: Mr. James F. O'Bryon.

Guest of Honor – Mr. James F. O'Bryon

Mr. James O'Bryon's career began at IBM's R&D Center in NY while still in undergraduate school. Subsequent to this, he took a position in the Actuarial Department of New York Life. The Army drafted him in December 1964 and this moved him into the T&E world. He held RDT&E positions at the Aberdeen Proving Ground from 1965-1986. In 1986, he accepted the position as the first Director, Live Fire Testing in the Pentagon and retired from the Pentagon, November 2001 as Dep. Dir. OT&E/LFT&E, a Deputy Assistant Secretary of Defense position. Jim has an undergraduate math degree and graduate degrees from GWU in Ops Research and from MIT in Electrical Engineering.

Jim has chaired the NDIA T&E Division for 14 years and chaired dozens of national and international T&E Conferences. He has taught T&E at NDU, ICAF, NPS, University of Texas and other places for nearly 20 years and authored over 90 technical reports and 80 open literature articles on T&E and related issues. He has just completed an 800-page book on Lessons Learned from Live Fire Testing and has testified before Congress on several occasions on T&E and Aviation Security. He has received the ADPA Gold Medal, the NDIA Gold Medal, the Arthur Stein Award for Excellence in Live Fire Testing and numerous DoD Awards including two personally presented by two different Secretaries of Defense. He now chairs a Committee of the National Academy of Sciences, as well as serving as a consultant to several commercial and not-for-profit institutions.

Previous Recipients

2006: *RADM Bert Johnston, USN (Ret), Wyle Laboratories*
2005: *Hon Thomas Christie, DOT&E, OSD*
2004: *Dr. Marion L. Williams, Headquarters AFOTEC*
2003: *Mr. James W. Fasig, Aberdeen Test Center*
2002: *Mr. G. Thomas Castino, Underwriters Laboratories, Inc.*
2001: *Hon Philip E. Coyle, III, DOT&E, OSD*
2000: *Mr. Walter W. Hollis, Department of the Army*

Guest Speaker – Mr. Raymond Daddazio

It is our special privilege to welcome as our guest speaker, Mr. Raymond Daddazio, President, Weidlinger Associates, New York, NY. September 11, 2001 is a day we will always remember, and the scenes of the World Trade Center collapsing is forever etched in our minds.

Many were shocked not only by the aircraft attack against the buildings, but also see them collapse from the attack, resulting in a huge loss of life and property. Weidlinger Associates was called upon to lead the efforts to assess what and how the WTC collapsed and also how to mitigate a repeat of such a failure if future attacks occur on other major structures. Mr. Daddazio will share with us his insights into their analysis and recommendations.

Note: Guests wishing to attend with registrants are welcome to attend this Banquet. However, additional tickets must be purchased at the NDIA desk prior to the Banquet.

Wednesday, March 14, 2007

7:00 AM–8:00 AM	Continental Breakfast in the Display Area
7:00 AM – 5:00 PM	Conference Registration

– Session E –
Session Chair: Mr. William Yeakel

8:00 AM	Call to Order and Remarks – *Mr. Sam Campagna, Director, Operations, NDIA*
8:05 AM	Warfighting in a Climate Warming World: The Expectations, the Options, and the Solutions – *Honorable Philip E. Coyle, III, Former Director, OT&E, OSD*
8:35 AM	A Concept for Suitability Assessment in Capabilities-Based T&E – *Dr. Vincent P. Roske, Institute for Defense Analyses*
9:05 AM	Reliability Growth as Applied to Military Systems – *Dr. Larry Crow, President, Crow Reliability Resources, Inc.*
9:35 AM	Overcoming the Lowest Bidder with Quality Products in Government Purchases – *Mr. William Britz, President, Federal Program Management*
10:05 AM	Morning Break & Networking in the Display Area

– Session F –
Session Chair: Mr. Dick Dickson

10:35 AM	Development, Test & Evaluation of Unmanned Ground Vehicles/Robots, *VADM Joseph Dyer, USN (Ret), President and General Manager, iRobot Corporation*
11:15 AM	Industry Panel: Sustainability KPP: Industry Weighs in on Bidding for It and Building for It – *Mr. John Stoddart, President, Defense Business, Oshkosh Truck* Past, Present & Future Trends in RM&A – *Mr. Ron Mutzelburg, Vice President, Boeing Phantom Works, DC*

12:00 Noon Annual Awards Luncheon

The Tester of the Year Awards are presented annually to civilian and military personnel supporting all of the military services and OSD. For each military service and OSD, an award is presented to the outstanding defense civilian, outstanding military, and outstanding supporting contractor.

***Note: Guests wishing to attend with registrants are welcome to attend this event. However, additional tickets must be purchased at the NDIA desk prior to the luncheon.*

Tester of the Year Award Winners

Military	Civilian	Contractor
MAJ Michele Patello, USA	*Mr. Dana Blankenbiller*	*Mr. Kenneth Van Allen*
Col Rich Stuckey, USAF	*Ms. Daria Stafford*	*Ms. Crystal Villarreal*
Capt Peter Sandness, USAF	*Mr. William Pope*	*Mr. Charles Reed*
LCDR Matthew Rising, USN	*Mr. Edward Lee Graham*	*Mr. Jerry Manthei*
Maj James Roudebush, USMC	*Mr. Trevor Strand*	*Mr. Todd Sweeney*

OSD Special Category

ATEC Counterterrorism Test & Evaluation Team

– Session G –

Session Chair: Mr. Jack Sheehan

1:15 PM — Coping with Reliability, Sustainability and Life Cycle Costs at DHS – *Dr. George Zarur, Science Advisor, Science and Technology, DHS*

1:45 PM — DT&E Panel: Systems Engineering and DT&E for System Sustainability

Chair: *Col Richard Stuckey, USAF, Principal Assistant Deputy Director for DT&E, OUSD (AT&L)/SSE*

Panelists: *Dr. David Jerome, Deputy Director of Air, Space and Information Operations, AF Materiel Command*

Mr. Ray Lytle, Director, Life Cycle Engineering, Raytheon Missile Systems

Mr. Brian Simmons, Director, US Army Evaluation Center, Army Test & Evaluation Command

Mr. Richard Shubert, VP and Chief Engineering, Lockheed Martin Integrated Systems and Solutions

3:15 PM — Afternoon Break & Networking in the Display Area

Wednesday, March 14, 2007 – Concurrent Focus Sessions

– Session H –

3:30 – 5:30 PM Test Methodology

Focus Session H4

BARNWELL BALLROOM

Session Chair: Dr. Lowell Tonnessen

FS H4.1 Revisiting Quantitative Methods for Evaluating Training Programs for Systems Undergoing OT – *Dr. Christopher Hekimian, SAIC*

FS H4.2 Producing Anywhere, Anytime Test, Evaluation and Diagnostics Capable Products to Eliminate the T&E Logistic Burden – *Mr. Ryan Kinney, Agilent Technologies*

FS H4.3 Ship Suitability Testing – Preparing for the Future – *Mr. Steve Fisher, NAVAIR, Patuxent River*

FS H4.4 Innovative Techniques to Solve Measurement and Detection Problems – *Dr. Michael Slocum, Air Academy Associates*

3:30 – 5:30 PM Test Planning

Focus Session H5

ARCHER EAST BALLROOM

Session Chair: Mr. Dick Dickson

FS H5.1 A Continuum of Testing for Military Systems – *Dr. Patricia Jacobs, NPS*

FS H5.2 CTEC (Collaborative Test & Evaluation Capability) and the Event Streaming Media System – *Mr. Reid Johnson, NUWC Keyport*

FS H5.3 Integrated Weapons System Testing – *Ms. Laura DeSimone, NSWC Dahlgren*

FS H5.4 Estimating Durations and Trials to Success in Test Trial Programs – *Dr. Danny Hughes, LMI*

FS H5.5 Operational Testing of Procedures is Critical to Effective Use/Integration of Emerging Capabilities: Report on Joint Space Control Operations – *Col Christian Daehnick, USAF, Negation Joint Test & Evaluation*

3:30 – 5:30 PM Technology to Reduce Life Cycle Cost

Focus Session H6

ARCHER WEST BALLROOM

Session Chair: Dr. Anne Hillegas

FS H6.1 T&E of Electromagnetic Railguns – *Mr. Thomas Boucher, NSWC Dahlgren*

FS H6.2 Cost Efficient Risk Management Through Integrated T&E Throughout the Systems Engineering Life-Cycle – *Mr. Joseph Tribble, AVW Technologies*

FS H6.3 Sustainment of the Deployed Navy Munitions Inventory Through Continuous Quality Evaluation Test & Evaluation – *Mr. Jeffrey Johnson, Navy Indianhead*

5:30 PM — Display Area Closed for the Day

Thursday, March 15, 2007

7:00 AM – 8:00 AM — Continental Breakfast in the Display Area

7:00 AM – 5:00 PM — Conference Registration

– Session I –

Session Chair: Mr. Jack Sheehan

8:00 AM — Call to Order and Remarks – *Mr. Sam Campagna, Director, Operations, NDIA*

8:05 AM — Suitability – At What Cost? – *Dr. Paul Alfieri, DAU*

8:10 AM — Service T&E Executives Speak
Chair: *Mr. Walt Hollis, Former DUSA/OR*
Panelists: *Mr. Dave Duma, Principal Deputy, DOT&E*
Dr. Hank Dubin, Army T&E
Mr. David Hamilton, Deputy Director, AF/TE
Mr. Steven Whitehead, OPTEVFOR

9:05 AM — The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability – *Dr. Ernest Seglie, DOT&E*

9:30 AM — Army T&E – Providing Essential Information to an Army at War – *Mr. Brian Simmons, Army DTC*

10:00 AM — Morning Break & Networking in the Display Area (Last Opportunity to Visit Displays)

– Session J –

Session Chair: Mr. William Yeakel

10:20 AM — Reliability-Based Design, Development and Sustainment – *Dr. Anne Hillegas, Applied Research Associates*

11:15 AM — Synthesis Panel**: Actions and Conference Takeaways
Chair: *Dr. Ernest Seglie, Science Advisor, DOT&E*
Panelists: *Mr. Stephen Daly, DDOT&E, Conventional Systems*
Mr. Chris DiPetto, Deputy Director for DT&E, OUSD (AT&L)/SSE
Ms. Diana Echols, Director of Customer Service Technology, Bell Helicopter Textron
Mr. Steven Whitehead, Technical Director, OPTEVFOR

**The discussion of this panel on the overall thrust of the Conference will serve as the basis of a White Paper and an overview article to be published in NDIA's *National Defense* Magazine.

11:55 AM — Conference Closing Remarks – *Mr. James O'Bryon, Chairman, NDIA Test & Evaluation Division*

Note: Please be sure to return your completed survey forms to the NDIA registration desk.

"The Department of Defense finds this event meets the minimum regulatory standards for attendance by DoD employees. This finding does not constitute a blanket approval or endorsement for attendance. Individual DoD component commands or organizations are responsible for approving attendance of its DoD employees based on mission requirements and DoD regulations."

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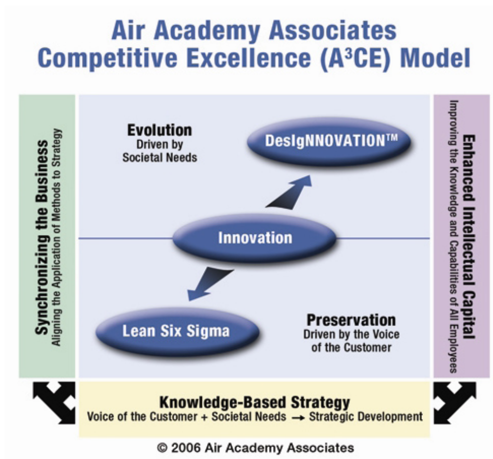

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- Utilizing mature and experienced consultants who are proficient at problem-solving and who excel as classroom instructors and knowledge transfer agents
- Incorporating advanced methods and techniques such as Robust Design, Tolerance Allocation, Expected Value Analysis, Axiomatic Design, etc., into our programs to optimize current performance and to enhance design and development phases
- Developing supplemental strategic alliances to insure that our clients' needs are met and enabling clients to achieve quick self-sustainability

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See you next year at the 24th Annual National Test & Evaluation Conference!

Hilton Palm Springs, CA • February 25 - 28, 2008

23rd Annual National Test & Evaluation Conference

"Test & Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems"

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Suitability . . . at what cost?

"5-minute" warm-up act for the T&E Service Exec Panel

Talk about 3 things:

1. New "Materiel Availability" KPP
2. DAU Suitability Research Project
3. Announce NDIA/DAU TST-301 2007 *All-Star Team !*

THE JOINT STAFF
WASHINGTON, D.C. 20318-8000

JOINT REQUIREMENTS
OVERSIGHT COUNCIL

JROCM 161-06
17 August 2006

MEMORANDUM FOR: Under Secretary of Defense for Acquisition, Technology, and Logistics
Commander, US Joint Forces Command
Vice Chief of Staff, US Army
Vice Chief of Naval Operations
Vice Chief of Staff, US Air Force
Assistant Commandant of the Marine Corps

Subject: Key Performance Parameter Study Recommendations and Implementation

1. The Joint Requirements Oversight Council (JROC) approved the Key Performance Parameter (KPP) Study recommendations. The JROC endorses the implementation of a mandated Materiel Availability KPP with supporting key system attributes of materiel reliability and ownership cost for all Major Defense Acquisition Programs (MDAPs) and select ACAT II and III programs. The JROC also endorsed selectively applying an Energy Efficiency KPP and a System Training KPP, as appropriate.

2. To better ensure the correct KPPs are selected, the JROC endorsed the use of KPP reference sheets produced as part of this study. The KPP reference sheets will be used as an aid in the process of identifying and validating potential KPPs for any acquisition program.

3. Implementation of the study recommendations will be concurrent with the publishing of the next revision of CJCS 3170-series documents. The revision will incorporate the details of the execution and will be coordinated for final release by 31 October 2006. Specific JROC implementation due backs and approved recommendations are enclosed.

E. P. GIAMBASTIANI
Admiral, US Navy
Vice Chairman
of the Joint Chiefs of Staff

Enclosure

JROC Memo: **17 Aug 2006**

(Subj: Key Performance Parameters Study Recommendations and Implementation)

1. Endorsed Mandatory "MATERIEL AVAILABILITY" Key Performance Parameter (KPP) for all MDAPs and Select ACAT II and III

With 2 Supporting Key System Attributes (KSAs):

A. Materiel Reliability KSA

B. Ownership Costs KSA

2. Endorsed ENERGY EFFICIENCY KPP for selected programs, as appropriate

3. Endorsed TRAINING KPP for selected programs, as appropriate

4. Did not endorse requirement for mandatory KPPs for these criteria:

COST

TIME and/or SCHEDULE

SUSTAINMENT

COALITION INTEROPERABILITY

FORCE PROTECTION AND SURVIVABILITY

JROC Approved Mandatory Sustainment KPP and KSAs*

- **<u>Single KPP:</u>**
  - **Materiel Availability** (= $\frac{\text{Number of End Items Operational}}{\text{Total Population of End Items}}$)
- **<u>Mandatory KSAs:</u>**
  - **Materiel Reliability** (MTBF)(= $\frac{\text{Total Operating Hours}}{\text{Total Number of Failures}}$)
  - **Ownership Cost** (O&S costs associated w/materiel readiness)
- **For mission success, Combatant Commanders need:**
  - Correct number of operational end items <u>capable</u> of performing the mission when needed
  - Confidence that systems will perform the mission and return home safely without failure
- **Ownership Cost provides balance; solutions cannot be availability and reliability "at any cost."**

****JROC Approval Letter JROCM 161-06 Signed 17 Aug 06; Revised CJCS 3170 will put into Policy***

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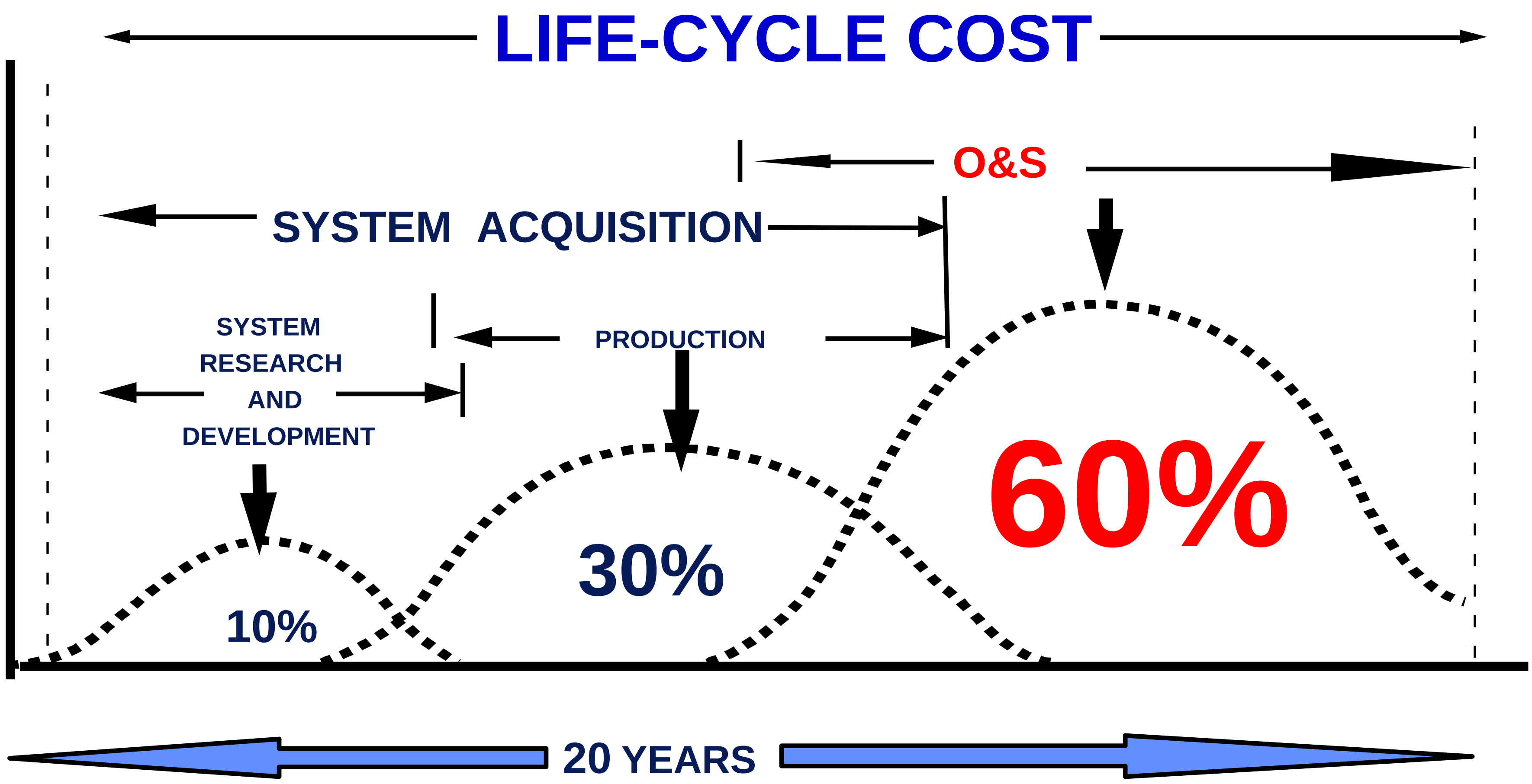
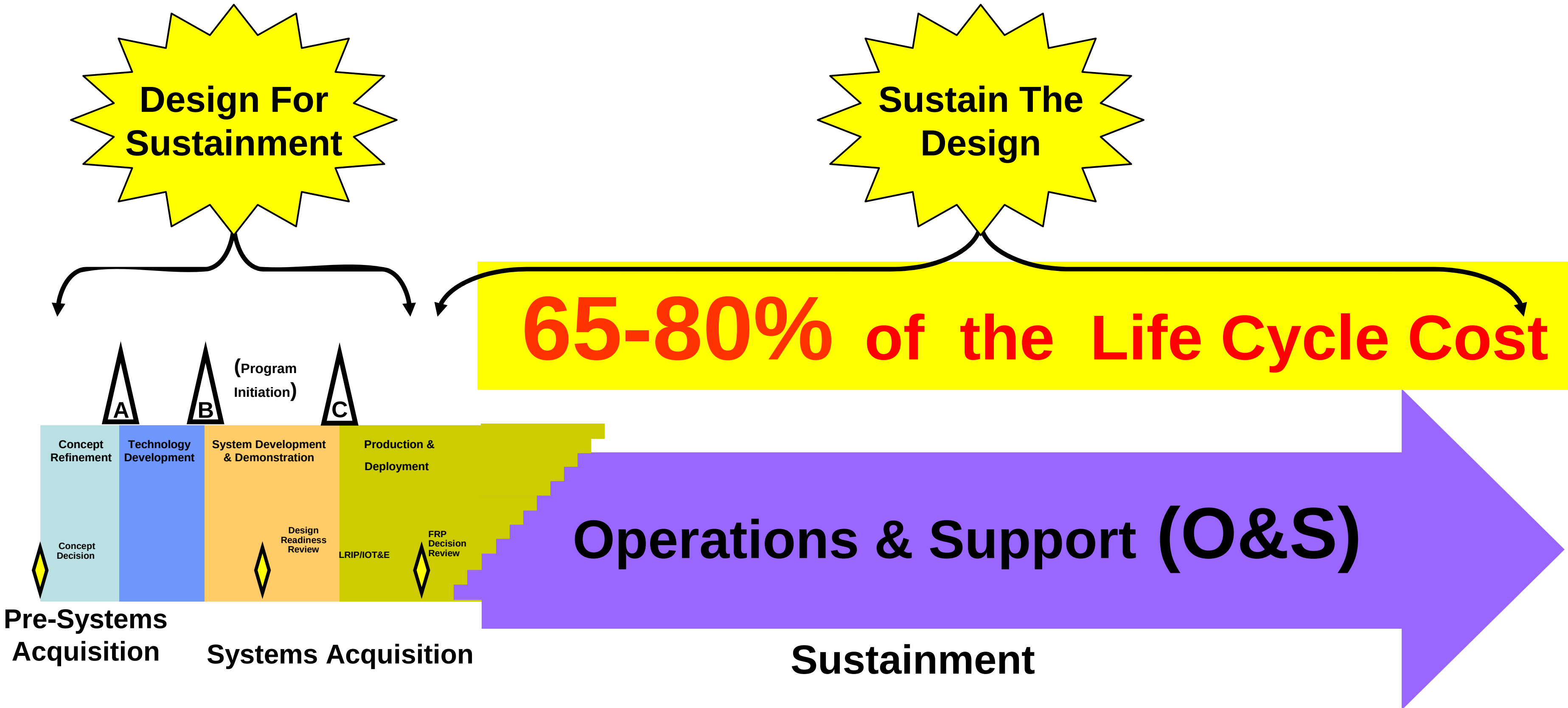


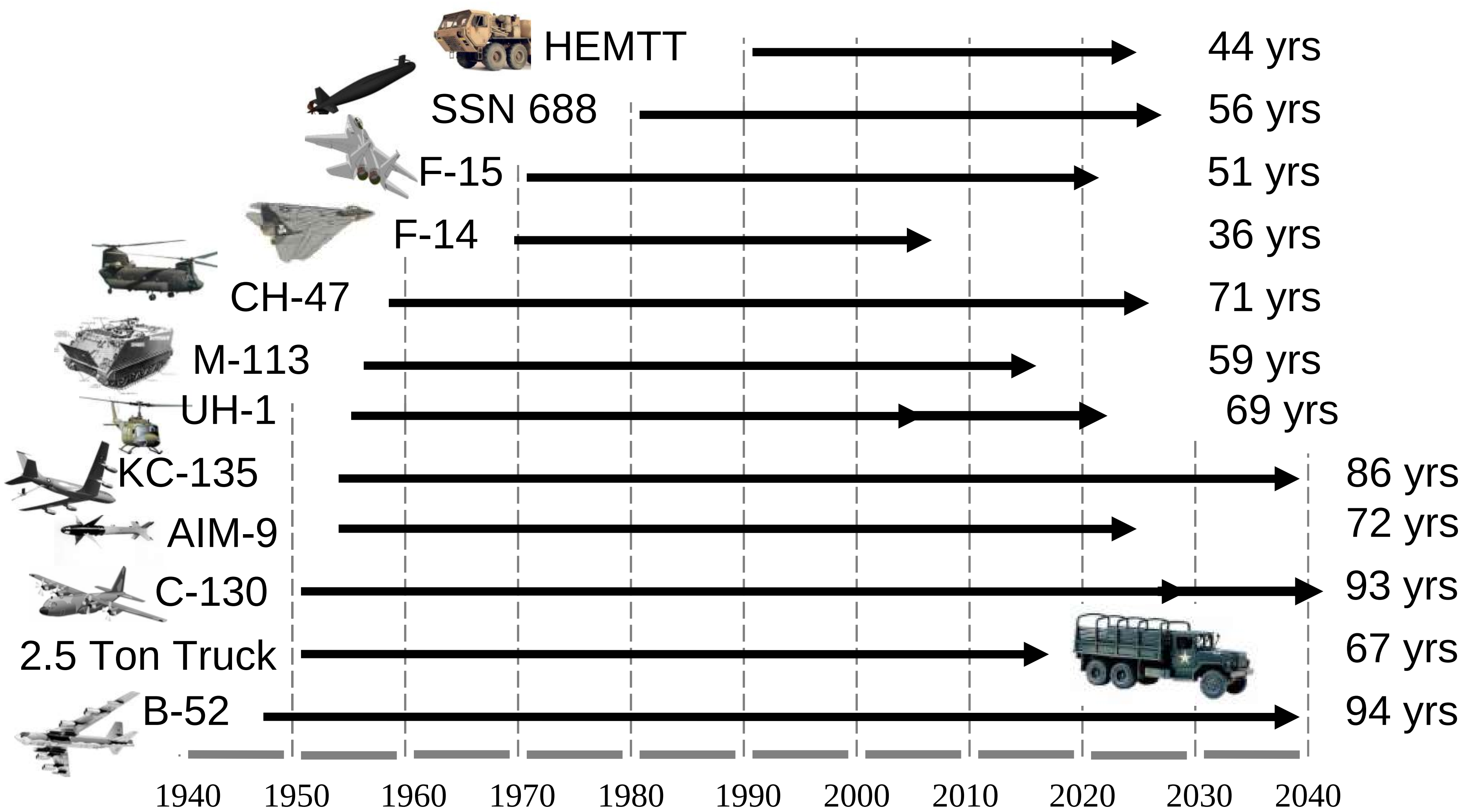
Life Cycle Management



O&S Costs Are Determined Early In The Acquisition Phase

USD(AT&L) FY 07 Strategic Goals (#4) Emphasize Sustainment Outcomes Throughout The Life Cycle Management Process

Defense System Life Cycles

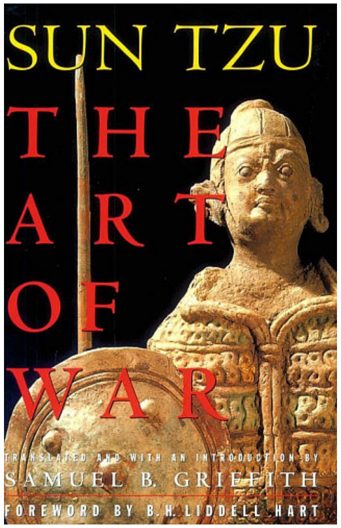


SOURCE: John F. Phillips DUSD (L)

Life Cycle Costing Considerations

"As Government expenditures, those due to broken down chariots, worn-out horses, armor and helmets, arrows, and crossbows, lances, hand and body shields, draft animals and supply wagons will amount to 60% of the total."

Sun Tzu (The Art of War, 6th Century B.C.)



Suitability . . . at what cost?

DAU Research Project:

"STRYKER Suitability Analysis"

Dr. Paul Alfieri,
Director of Research
Defense Acquisition University
paul.alfieri@dau.mil
(703) 805-5282

Dr. Don McKeon,
Professor of Engineering Management
Defense Acquisition University
mckeond@tacom.army.mil
(586) 574-7240

Suitability . . . at what cost?

Typical IOT&E Evaluation Results:

EFFECTIVENESS: approximately 90% success rate

SUITABILITY: approximately 60 - 75% success rate

Typical Decision after IOT&E: Begin fielding ASAP, even <u>before</u> . . . .

Suitability problems are addressed

Reliability is improved

Maintenance procedures are mature

Training is complete

. . . .

. . . .

Why field before addressing these problems? Urgent Combat Need

The QUESTION: How much does it cost us to do business this way?

Suitability . . . at what cost?

DAU Research Study Proposal

Investigate various types of systems

Total of 5 or 6, several from each service

Criteria:

Recently fielded

Evaluated to be Effective but not "fully" Suitable

Examine performance of systems wrt suitability

Determine suitability cost drivers

Evaluate suitability trends

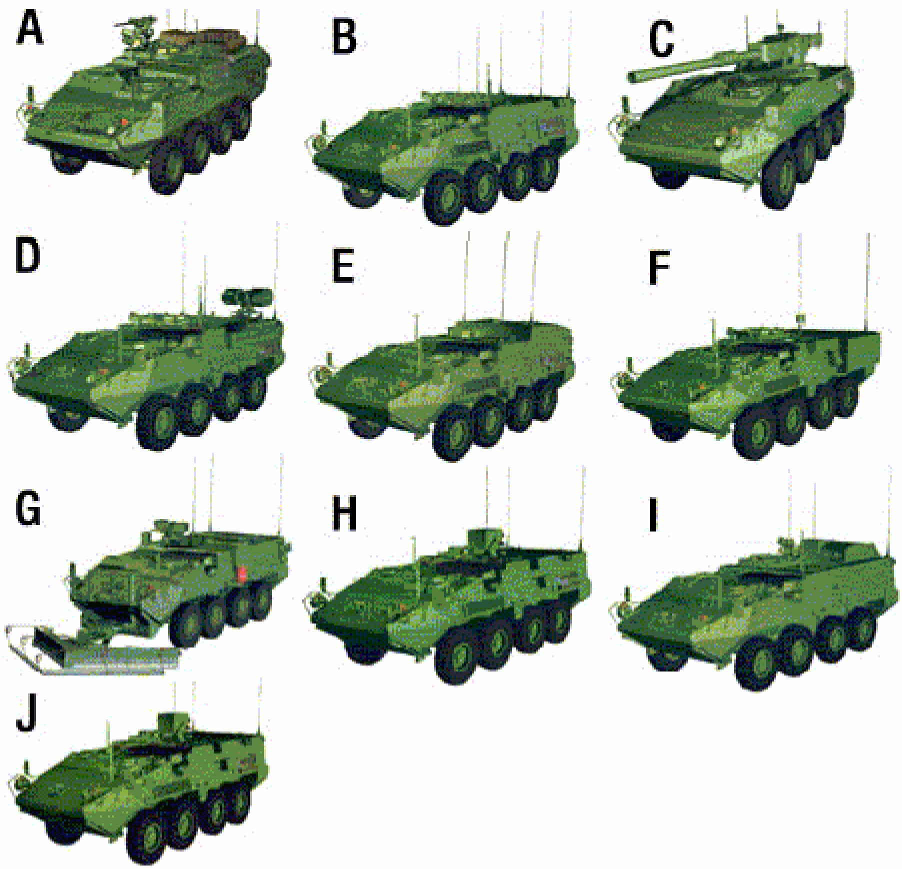
Sponsor Decision: Start with one program, work from there . . . . .

First Program Selected: STRYKER Family of Vehicles

Additional Study Candidates: TBD

STRYKER FAMILY OF VEHICLES

In service with the US Army



Legend

A. Infantry Carrier Vehicle B. Command Vehicle C. Mobile Gun System

D. Fire Support Vehicle E. Medical Evacuation F. Mortar Carrier

G. Engineer Squad Vehicle H. Anti-tank Guided Missle I. NBC Reconnaissance

J. Reconnaissance Vehicle

Results to date:

– Analysis of CDRL data ongoing

– Established process and methodology

– Developed parametric models

– **GOAL: independent CPM determination**

Cost Per Mile (CPM) Estimates

- **CPM estimate - $17.19 (GAO 04-925, including labor, parts & repair)**
- **CPM estimate - $18.78 (Stryker R-TOC Brief)**
- **CPM estimate - $18.23 (based on M113 methodology w/Stryker adjustments)**
- **CPM estimate - $14.53 (based on initial 4 month deployment data)**

Current:

- **CPM estimate (GDLS) - $13.52 garrison**
  $ 8.88 deployed

- **DAU CPM estimate – $ 13.30 garrison**
  $ 7.95 deployed

Recommendations

- Continue Research
  - Complete Stryker analysis
- Feedback from sponsor
- Feedback from community
- Determine path ahead
- Develop methodology for conducting suitability studies on other systems
- Look at other programs for comparison
  - Other services, other types of systems

NDIA/DAU TST-301 2007 All Stars

1B – Mr. Steve Whitehead, (COMOPTEVFOR)

2B – Col Mike Bohn, USMC (MCOTEA)

3B – Joe Wascavage, (NAVAIR)

SS – Brian Simmons, (ATEC)

LF – Rick Lockhart, (DTRMC)

CF – Dave Duma, (DOT&E)

RF – Steve Zink, (OSHKOSH TRUCKS)

C – Dr. Ernest Seglie, (DOT&E)

P – Jim O'Bryon, CIVLANT (NDIA)

Pinch Hitters: **COL Sam Kyle, USAF (AFOTEC)**

CAPT Rick Scudder, USN (formerly OP-091)

Mr. Pete Nolte, (AT&L)

Mr. Larry Leiby, (TEMA)

Mr. Fred Myers, (AT&L)

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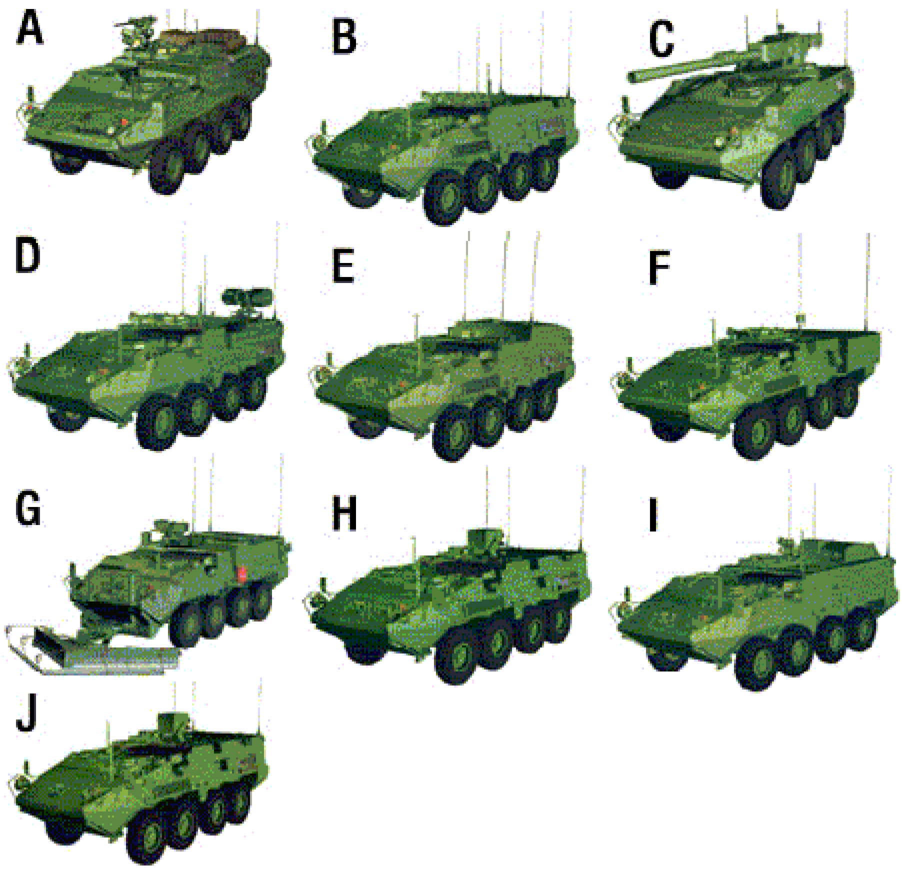

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D. Fire Support Vehicle
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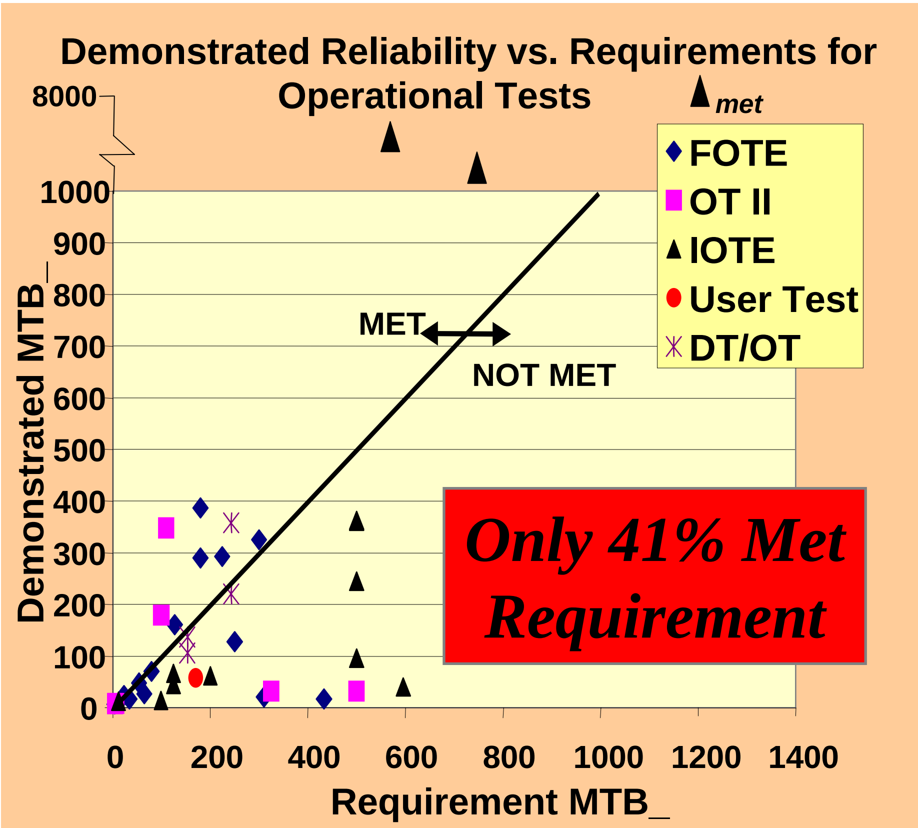
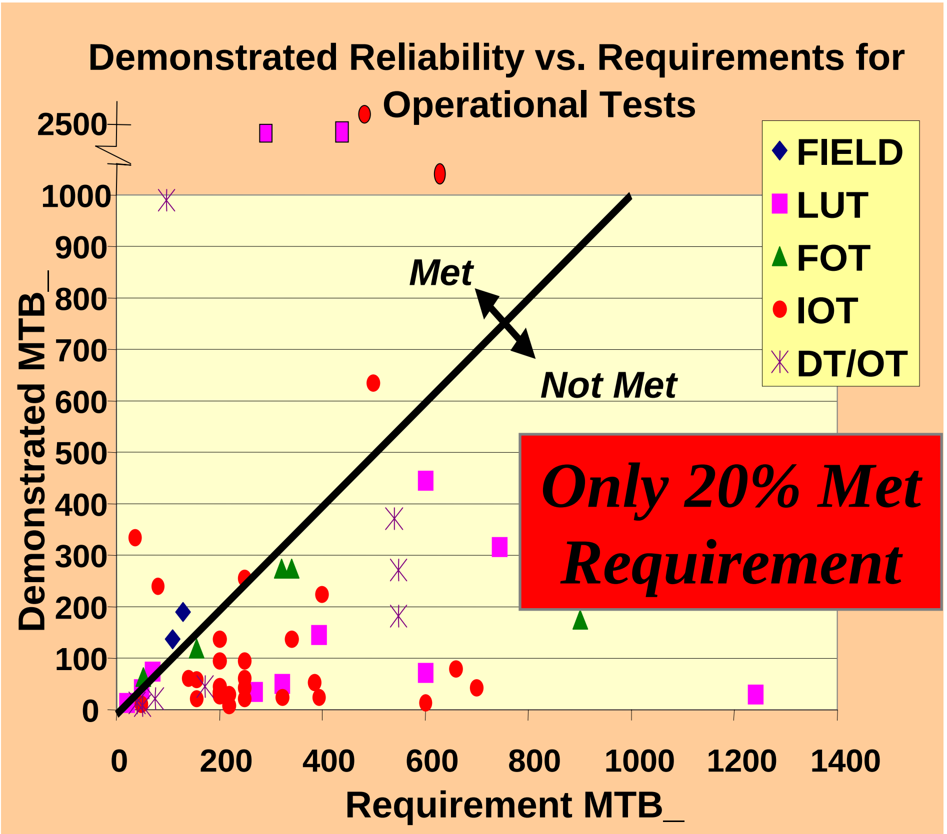
H. Anti-tank Guided Missle
I. NBC Reconnaissance
J. Reconnaissance Vehicle

Now, back to Suitability . . . .

ATEC Reliability Track Record



1985-1990



1996-2000

Most Of Our Systems Fail To Achieve Reliability Requirements In OT

. . . And The Trend Appears To Be Continuing Downward source: ATEC

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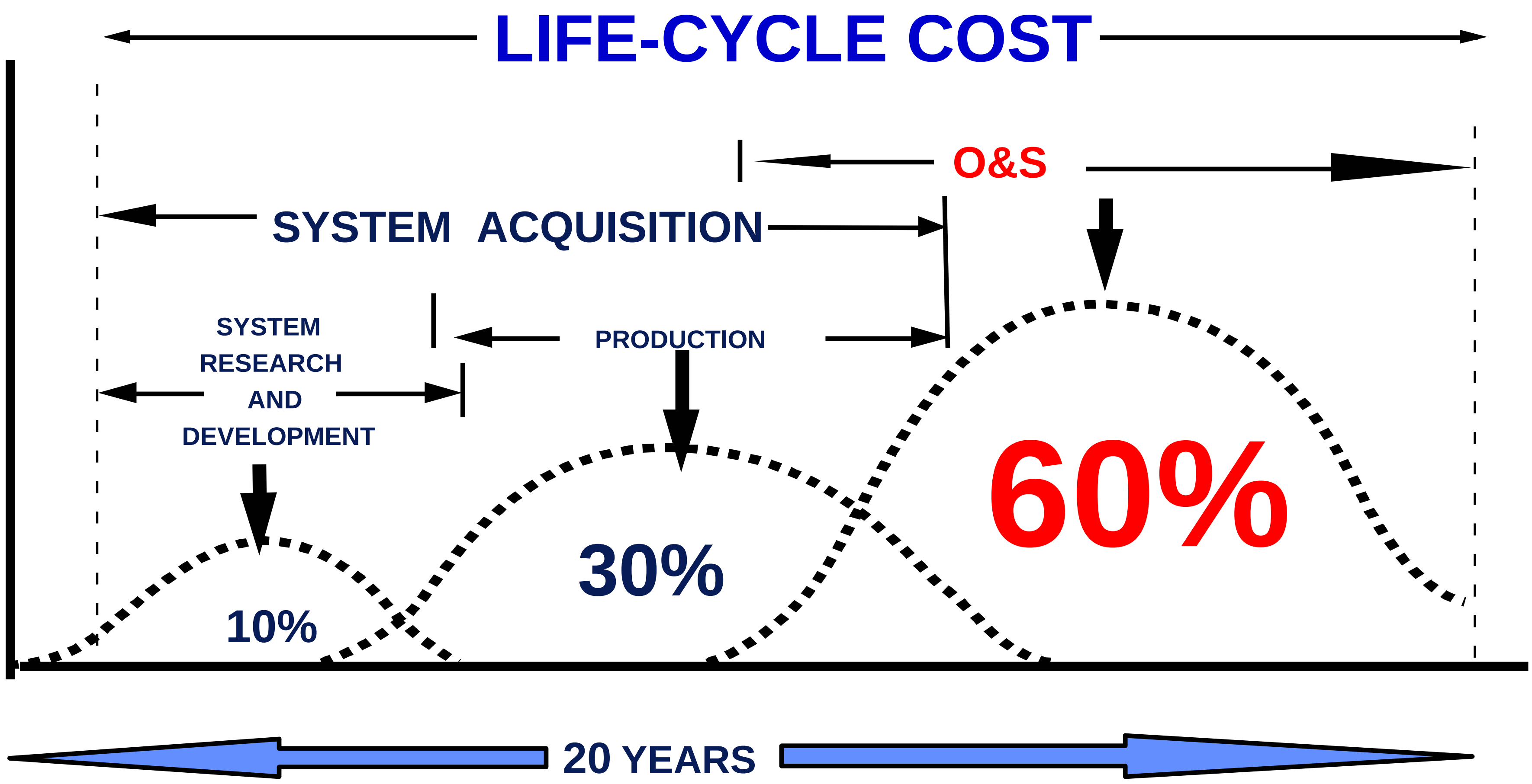

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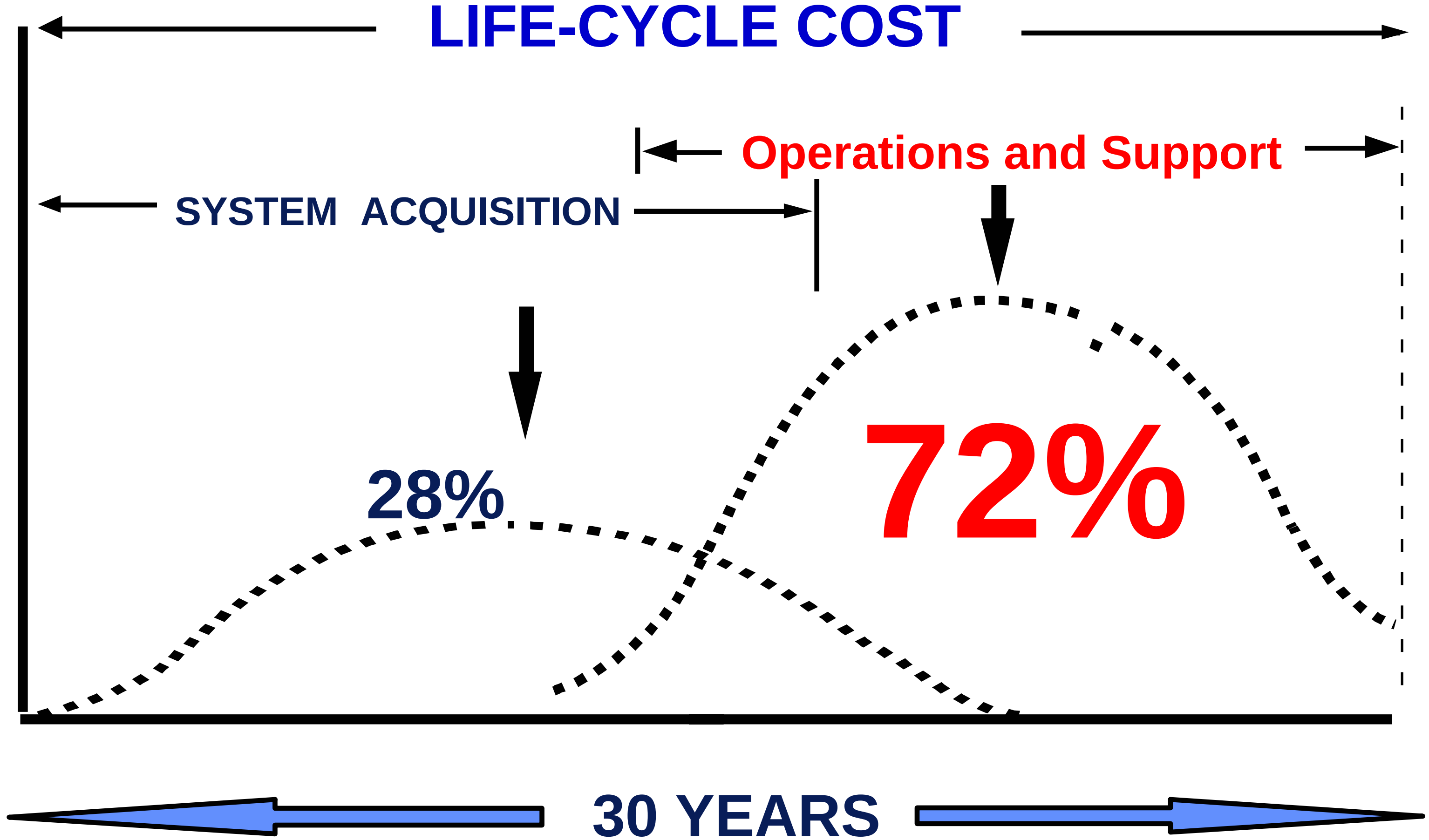
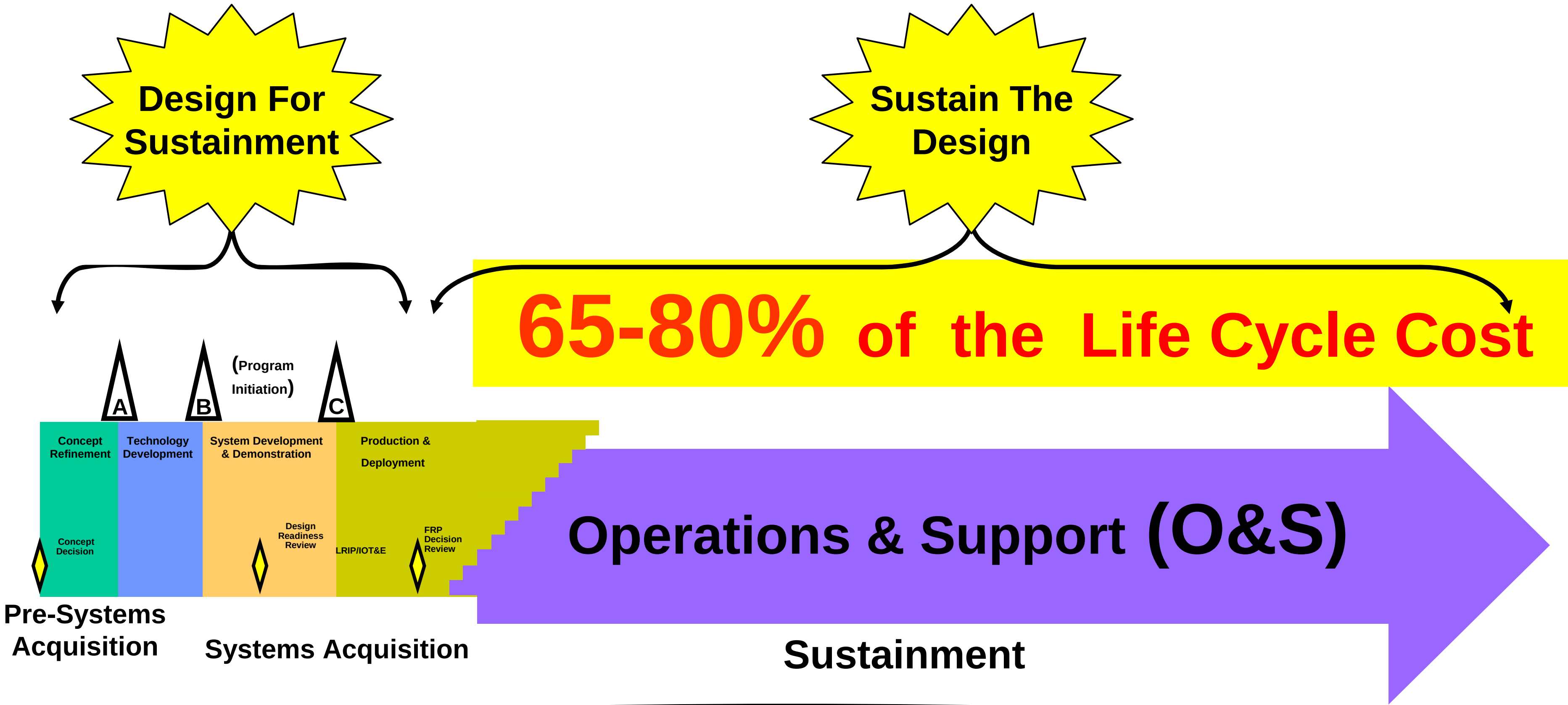


Life Cycle Management



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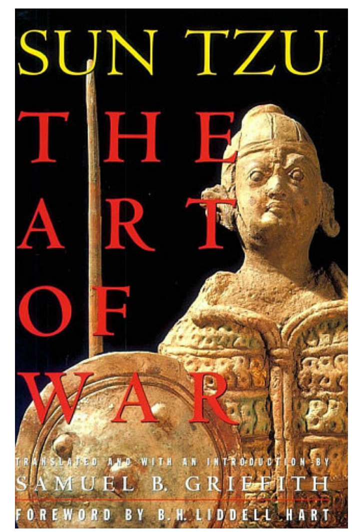
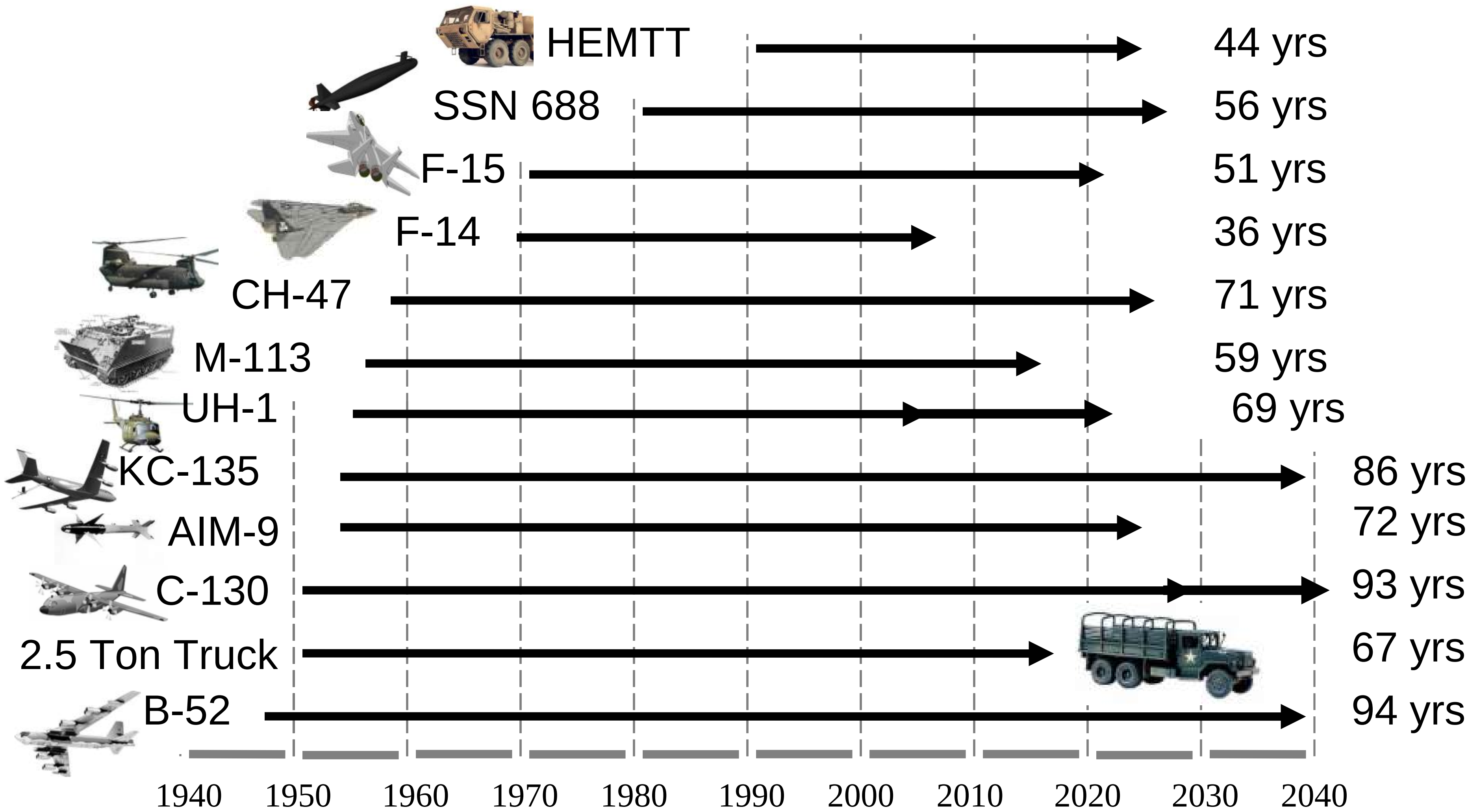


Defense System Life Cycles



SOURCE: John F. Phillips DUSD (L)

DoD Directive

(5000.1)

“PMs shall consider supportability, life cycle costs, performance, and schedule comparable in making program decisions.”

Department of Defense
DIRECTIVE

NUMBER 5000.1
May 12, 2003

USD(AT&L)

SUBJECT: The Defense Acquisition System

References:

(a) DoD Directive 5000.1, “The Defense Acquisition System,” October 23, 2000 (hereby canceled)
(b) DoD Instruction 5000.2, “Operation of the Defense Acquisition System,” May 12, 2003
(c) DoD 5025.1-M, “DoD Directives System Procedures,” current edition
(d) Title 10, United States Code, “Armed Forces”
(e) Section 2350a of title 10, United States Code, “Cooperative Research and Development Projects: Allied Countries”
(f) Section 2751 of title 22, United States Code, “Need for international defense cooperation and military export controls; Presidential waiver; report to Congress; arms sales policy”
(g) Section 2531 of title 10, United States Code, “Defense memoranda of understanding and related agreements”
(h) Federal Acquisition Regulation (FAR), current edition
(i) Section 1004, Public Law 107-314, “Bob Stump National Defense Authorization Act for Fiscal Year 2003,” “Development and Implementation of Financial Management Enterprise Architecture”
(j) DoD Directive 8500.1, “Information Assurance (IA),” October 24, 2002
(k) DoD Directive 4630.5, “Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS),” January 11, 2002
(l) DoD Directive 2060.1, “Implementation of, and Compliance with, Arms Control Agreements,” January 9, 2001

1. PURPOSE

This Directive:

1.1. Reissues reference (a) and authorizes publication of reference (b).

1.2. Along with reference (b), provides management principles and mandatory policies and procedures for managing all acquisition programs.

2. APPLICABILITY AND SCOPE

2.1. This Directive applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all organizational entities within the Department of Defense (hereafter collectively referred to as "the DoD Components").

2.2. The policies in this Directive apply to all acquisition programs.

AT&L Memo: **22 Nov 2004**

(Subj: Total Life Cycle Systems Management (TLCSM) Metrics)

Emphasizes use of PBL (Performance-Based Logistics) for all weapons

Provides Specific Definitions (and Formulas) for the following metrics:

1. **Ao (Operational Availability)**
2. **Mission Reliability**
3. **TLCS Cost per Unit of Usage**
4. **Cost per Unit of Usage**
5. **Logistics Footprint**
6. **Logistics Response Time**

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

NOV 2 2 2005

ACQUISITION, TECHNOLOGY AND LOGISTICS

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
(ATTN: SERVICE ACQUISITION EXECUTIVES)

SUBJECT: Total Life Cycle Systems Management (TLCSM) Metrics

The Defense Business Board recommended to the Deputy Secretary of Defense that the Department aggressively pursue implementation of Performance-Based Logistics, for all its weapons, new and legacy.

In a memorandum dated August 16, 2004, my predecessor directed measuring performance in terms of Operational Availability, Mission Reliability, Cost per Unit of Usage, Logistics Footprint, and Logistics Response time. For consistency, this memorandum provides specific definitions of those metrics for use across the Department (attached). I direct their use as the standard set of metrics for evaluating overall TLCSM.

I also direct the TLCSM Executive Council to develop a "TLCSM Metrics Handbook," with specific metrics, formulas and calculation methodologies. It will be used in performance-based contracts and for sustainment oversight. The handbook will also define supporting data requirements that should be incorporated into emerging logistics information systems.

The principal point of contact for administration of the handbook is Mr. Lou Kratz, Assistant Deputy Under Secretary of Defense (Logistics Plans and Programs), 703-614-6327, Louis.Kratz@osd.mil.

Kenneth J. Krieg

Attachment:
As stated

JROC Memo: **17 Aug 2006**

(Subj: Key Performance Parameters Study Recommendations and Implementation)

1. **Endorsed Mandatory "MATERIEL AVAILABILITY" Key Performance Parameter (KPP) for all MDAPs and Select ACAT II and III**

   With 2 Supporting Key System Attributes (KSAs):

   A. Materiel Reliability KSA

   B. Ownership Costs KSA

2. **Endorsed ENERGY EFFICIENCY KPP for selected programs, as appropriate**

3. **Endorsed TRAINING KPP for selected programs, as appropriate**

4. **Did <u>not</u> endorse requirement for mandatory KPPs for these criteria:**

   COST

   TIME and/or SCHEDULE

   SUSTAINMENT

   COALITION INTEROPERABILITY

   FORCE PROTECTION AND SURVIVABILITY

THE JOINT STAFF
WASHINGTON, D.C. 20318-8000

JOINT REQUIREMENTS OVERSIGHT COUNCIL

JROCM 161-06
17 August 2006

MEMORANDUM FOR: Under Secretary of Defense for Acquisition, Technology, and Logistics
Commander, US Joint Forces Command
Vice Chief of Staff, US Army
Vice Chief of Naval Operations
Vice Chief of Staff, US Air Force
Assistant Commandant of the Marine Corps

Subject: Key Performance Parameter Study Recommendations and Implementation

1. The Joint Requirements Oversight Council (JROC) approved the Key Performance Parameter (KPP) Study recommendations. The JROC endorses the implementation of a mandated Materiel Availability KPP with supporting key system attributes of materiel reliability and ownership cost for all Major Defense Acquisition Programs (MDAPs) and select ACAT II and III programs. The JROC also endorsed selectively applying an Energy Efficiency KPP and a System Training KPP, as appropriate.

2. To better ensure the correct KPPs are selected, the JROC endorsed the use of KPP reference sheets produced as part of this study. The KPP reference sheets will be used as an aid in the process of identifying and validating potential KPPs for any acquisition program.

3. Implementation of the study recommendations will be concurrent with the publishing of the next revision of CJCS 3170-series documents. The revision will incorporate the details of the execution and will be coordinated for final release by 31 October 2006. Specific JROC implementation due backs and approved recommendations are enclosed.

E. P. Giambastiani

E. P. GIAMBASTIANI
Admiral, US Navy
Vice Chairman
of the Joint Chiefs of Staff

Enclosure

JROC Approved Mandatory Sustainment KPP and KSAs*

- **<u>Single KPP:</u>**
  - **Materiel Availability** $\left(= \frac{\text{Number of End Items Operational}}{\text{Total Population of End Items}}\right)$
- **<u>Mandatory KSAs:</u>**
  - **Materiel Reliability** (MTBF) $\left(= \frac{\text{Total Operating Hours}}{\text{Total Number of Failures}}\right)$
  - **Ownership Cost** (O&S costs associated w/materiel readiness)
- **For mission success, Combatant Commanders need:**
  - Correct number of operational end items <u>capable</u> of performing the mission when needed
  - Confidence that systems will perform the mission and return home safely without failure
- **Ownership Cost provides balance; solutions cannot be availability and reliability "at any cost."**

****JROC Approval Letter JROCM 161-06 Signed 17 Aug 06; Revised CJCS 3170 will put into Policy***

Proposed Life Cycle Sustainment Outcome Metrics

- **Materiel Availability (KPP*)**
  - A Key Data Element Used In Maintenance And Logistics Planning
- **Materiel Reliability (KSA*)**
  - Provides A Measure Of How Often The System Fails/Requires Maintenance
  - Another Key Data Element In Forecasting Maintenance/Logistics Needs
- **Ownership Cost (KSA*)**
  - Focused On The Sustainment Aspects Of The System
  - An Essential Metric For Sustainment Planning And Execution
  - Useful For Trend Analyses – Supports Design Improvements/Modifications
- **Mean Downtime**
  - A Measure Of How Long A System Will Be Unavailable After A Failure
  - Another Key Piece Used In The Maintenance/Logistics Planning Process
- **Other Sustainment Outcome Metrics May Be Critical To Specific Systems, And Should Be Added As Appropriate**

* Sustainment KPP & KSAs Included In Revised Draft CJCSM 3170

These 4 Life Cycle Sustainment Outcome Metrics Are Universal Across All Programs And Are Essential To Effective Sustainment Planning

DUSD AT&L Metrics Evolution

TLCSM Metrics (Nov 05)	Life Cycle Sustainment Metrics (Feb 07)
• *Operational Availability (A_o)*	• **Materiel Availability** • *Key Performance Parameter (KPP) (per Aug 06 JROC Memo)*
• *Mission Reliability*	• **Materiel Reliability** • *New Key System Attribute (KSA) (per Aug 06 JROC Memo)*
• *Total Life Cycle System Cost per Unit of Usage* • *Cost Per Unit of Usage*	• **Ownership Cost** • *New Key System Attribute (KSA) (per Aug 06 JROC Memo)*
• *Logistics Footprint*	• *No Corresponding New Metric*
• *Logistics Response Time (LRT)*	• **Mean Down Time (MDT)**

DAU Stryker Suitability Study

- **Interim Progress Report #2**
  - Objectives
  - Process
  - Progress & Plans
  - Findings & Observations
  - Data Analysis
  - Reliability Measurement Issue
  - Challenges
  - Recommendations

DAU Stryker Suitability Study

- **Objectives**
  - To conduct a research study to quantify the difference between projected O&S (associated with the RAM requirement) and the actual costs associated with the achieved level of operational suitability. That is, quantify the costs of not achieving adequate levels of operational suitability.

Process

- **Phase 1- Initial Program (Stryker)**
  - a. Understand the problem
  - b. Define detailed study objectives
  - c. Collect data
  - d. Analyze data and build models
  - e. IPR at T&E Conference - Hilton Head
  - f. Acquire additional data as needed
  - g. Draft report
  - h. Finalize report

- **Phase 2 - Analysis of 5 additional programs covering multiple types**

Data Collection:

Phase 1 Sources

- Stryker PM Team (TACOM Warren, MI)
- AEC RAM Directorate (APG)
- OTC Reps (Ft. Hood)
- AT&L Rep
- IDA
- LMI
- GDLS CDRL Data
- Ft. Lewis Stryker Team

Findings & Observations

- **Warfighters very satisfied with Stryker performance in-theatre**
- **Brigade Commanders extremely happy with ICLS**
- **High Operational Readiness Rates, but ORR is prioritized over support costs**
- **Op Temp in-theatre far exceeds planned usage rates (X10, X15, X30 ?)**
- **Operational Environment much different than expected**
- **Combat configurations add excessive weight to vehicle (affecting reliability and performance)**
- **Army did not buy Tech Data Pkg – "Prohibitively expensive" . . . risk to government**

Findings & Observations

- **Operational Readiness Rate not necessarily consistent with traditional A_o (Operational Availability)**
  - RAM issues can be masked by ORR
- **Mission Completion vs. Subsystem Failure**
  - Possibly leads to overestimating system reliability due to non-reporting on individual subsystem (component) failures
  - Multi-mission vehicle – with subsystem failures, system can still perform alternate missions
- **Reporting Criteria Issue:**
  - ORR vs. MTBF of individual subsystems

Reliability Issues

- **Reliability requirement as defined in ORD**
  - **4.3.1.3. The Stryker (vehicle only, excluding GFE components/systems) will have a reliability of 1000 mean miles between critical failure (i.e., system aborts).**
- **Reliability issues and cost drivers found during DT/OT correlate well with fielded experience**

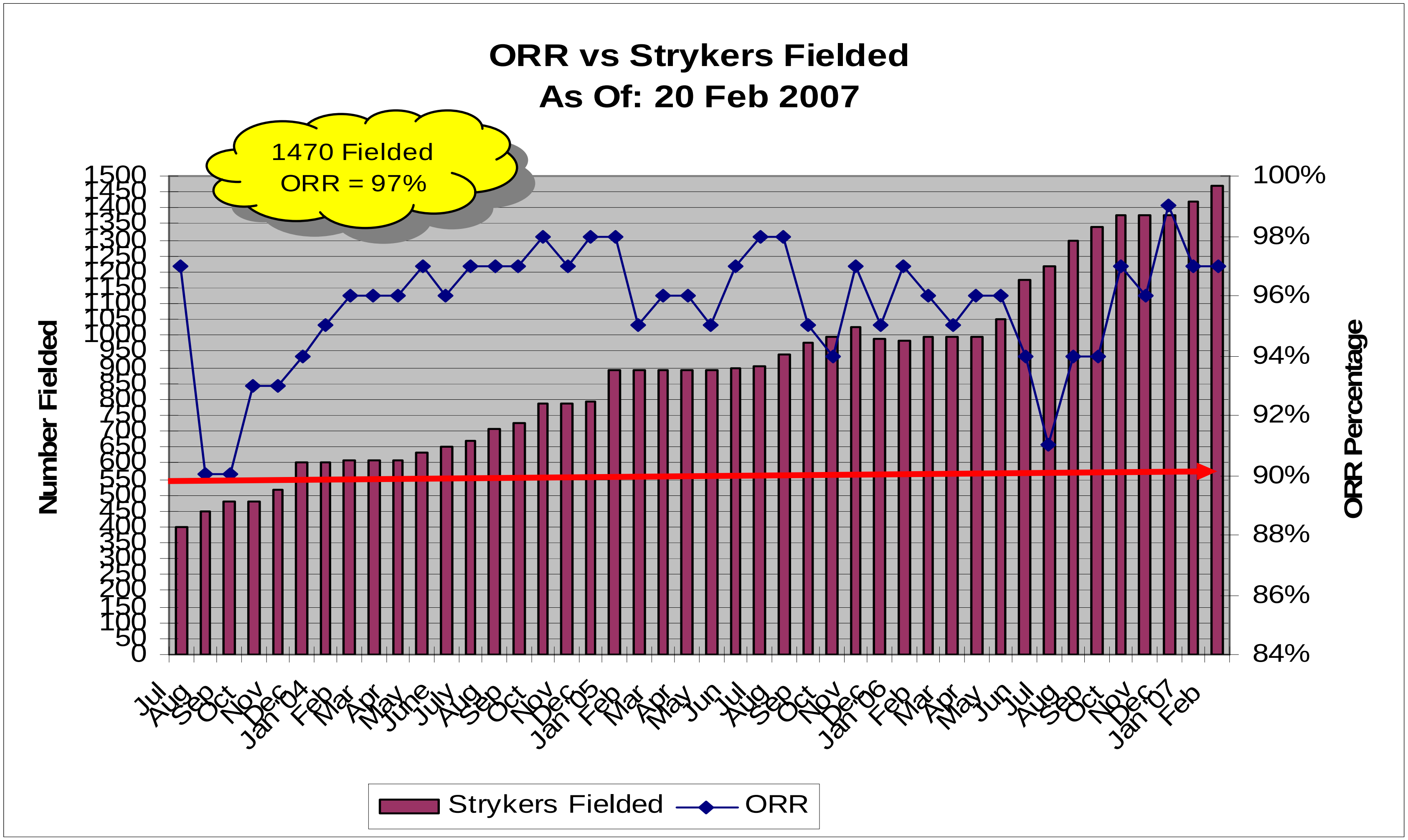
Operational Environment

- **Field usage much harsher than planned**
  - e.g., higher tire pressure, roads, curbs, weight (armor, sandbags)
- **Mission Profile says 80% XCountry, 20% Primary Roads**
  - in-theater mission just the opposite . . . most missions in urban environment (police action) on paved roads
- **OpTempo very high (>10X)**
  - High OpTempo may improve reliability numbers, but beats up equipment
  - With low usage, seals can dry up, humidity can build up in electrical components
- **Changes in mission & configuration are putting excess stress on vehicle: armor/sandbags, over inflated tires, going over curbs**
  - replacing 9 tires/day (>3200 tires/yr)
  - wheel spindles developing fatigue cracks
  - drive shafts breaking
  - prescribed tire pressure is 80 PSI, however, with slat armor/sandbags – must maintain >95 PSI
  - 95 PSI is a logistics burden on operators
    - Must be maintained by the soldier (tire inflation system can't do it)
    - Soldiers must check tire pressure more than 3 times per day to maintain 95 PSI

Tactical Considerations

- **Slat Armor design (additional 5000 lb) is effective for many RPG threats, but negatively impacts circumference, weight and performance of Stryker**
  - **Causes multiple problems for safe and effective operation**
    - **Slat armor on rear ramp too heavy - greatly strains lifting equipment**
      - **Occasionally, crews must assist raising/lowering ramp**
    - **Bolts on rear ramp break off frequently with normal use**
    - **Slat armor bends with continued ops . . . can cover escape hatches and block rear troop door in ramp**
    - **Slat armor interferes with driver's vision**
    - **Slat armor difficult for other traffic to see at night . . . Safety hazard in urban environment**
    - **Slat Armor prohibits normal use of exterior storage racks**
  - **Significantly impacts handling/performance in wet conditions**
    - **Adds excessive strain on engine, drive shafts, differentials**
  - **Impairs off-road ops**
- **Though not designed primarily for the urban fight (MOUT), Stryker is well-suited for it**
  - **Unlike M-1, Stryker is "ghostly" quiet . . . tactical advantage**
- **Stryker overall OIF performance significantly better than HUMVEE, BRADLEY or M-1 in this environment**

Stryker Fleet Readiness



Operational Readiness Rate (ORR)

- **Contractual requirement: ORR $\geq$ 90%**
  - **Does not include GFE (base vehicle configuration only)**
- **Stryker consistently above requirement**
  - **Current ORR 97% (20 Feb 07)**
- **Cost-plus-fixed-fee contract motivates GDLS to meet ORR . . . .**
  - **However, contract does <u>not</u> incentivise controlling costs . . . risk to government**
  - **Example – to repair cracked hyd res in power pack, whole power pack is replaced in field**

Cost Per Mile (CPM)

- **CPM is a planning tool used to project future budget requirements**
- **No specific value of CPM required by contract**
- **Govt/Kr both calculate CPM independently, and use results to negotiate parts cost forecasts to determine purchasing requirements**
- **For this research project, DAU is doing our own independent computation of CPM (garrison and deployed units) to validate other data and our methodology**

Cost Per Mile (CPM) Estimates

- CPM estimate - $17.19 (GAO 04-925, including labor, parts & repair)
- CPM estimate - $18.78 (Stryker R-TOC Brief)
- CPM estimate - $18.23 (based on M113 methodology w/Stryker adjustments)
- CPM estimate - $14.53 (based on initial 4 month deployment data)

- CPM estimate (GDLS) - $13.52 garrison
  $ 8.88 deployed
- DAU CPM estimate – $ 13.30 garrison
  $ 7.95 deployed

- Note 1 - We need to understand the basis for these estimates more thoroughly (assumptions, models, configurations, limitations . . .)
- Note 2 - Figures above are averages across all variants (deployed or garrison)
- Note 3 - CPM higher for garrison than deployed stryker ???

Why? A. While deployed, non-essential maintenance can be delayed until absolutely necessary . . . intervals between reported failures increases, CPM decreases

B. Maintenance more accessible/available in garrison – follow the book closer

C. Higher mi/day deployed . . . less labor/mi

Other Findings . . . cont.

- **Stryker initial deployment/fielding was extremely accelerated to meet urgent combat need**
  - **Result was that Army was doing these things concurrently:**
    - **Testing**
    - **Producing**
    - **Fielding**
    - **Conducting combat operations**

- **The threat and the operational environment were different than anticipated**

Other Findings . . . cont.

- **Immature Maintenance Procedures- many procedures have not been validated in IETMs (interactive electronic tech manuals) lead to:**
  - **"*Tribal System Maintenance*" from experienced crews (". . . that new book isn't any good . . . . this is the way it worked on the M113, so do it like this")**

- **With Kr support to maintain vehicles, soldier crews develop "*rental car mentality*" . . .**
  - **Lack of ownership mentality . . . overly dependent on contractor**
  - **Sometimes they forget the basics (oil check)**
  - **One vehicle lost because pre-mission checks were ignored**

DATA ANALYSIS

Phase 1 – March 2007

Data Collected

- CDRL A003 (Aug 2006)
  - Parts Consumption Report (for ~ 1 yr)
  - Good quality data (possibly some errors in mileage or dates)
- CDRL A004 (Aug 2006)
  - Repairable Items Repair Cost Summary
  - Most repair items have estimates or quotes

Cost Per Mile Analysis

$$\text{Cost Per Mile} = \frac{\text{Labor} + \text{Replacement Parts} + \text{Part Repair}}{\text{Total Vehicle Mileage}}$$

Labor : $4.73M per brigade (average value)

Replacement Parts : from CDRL A003 Consumption Report

Part Repair : No historical data for many parts

Variability in Part Repair

Existing data from CDRL A004

(Repairable Items Repair Cost Summary

Vehicle Mileage : Does not exist for all vehicles

Questionable accuracy

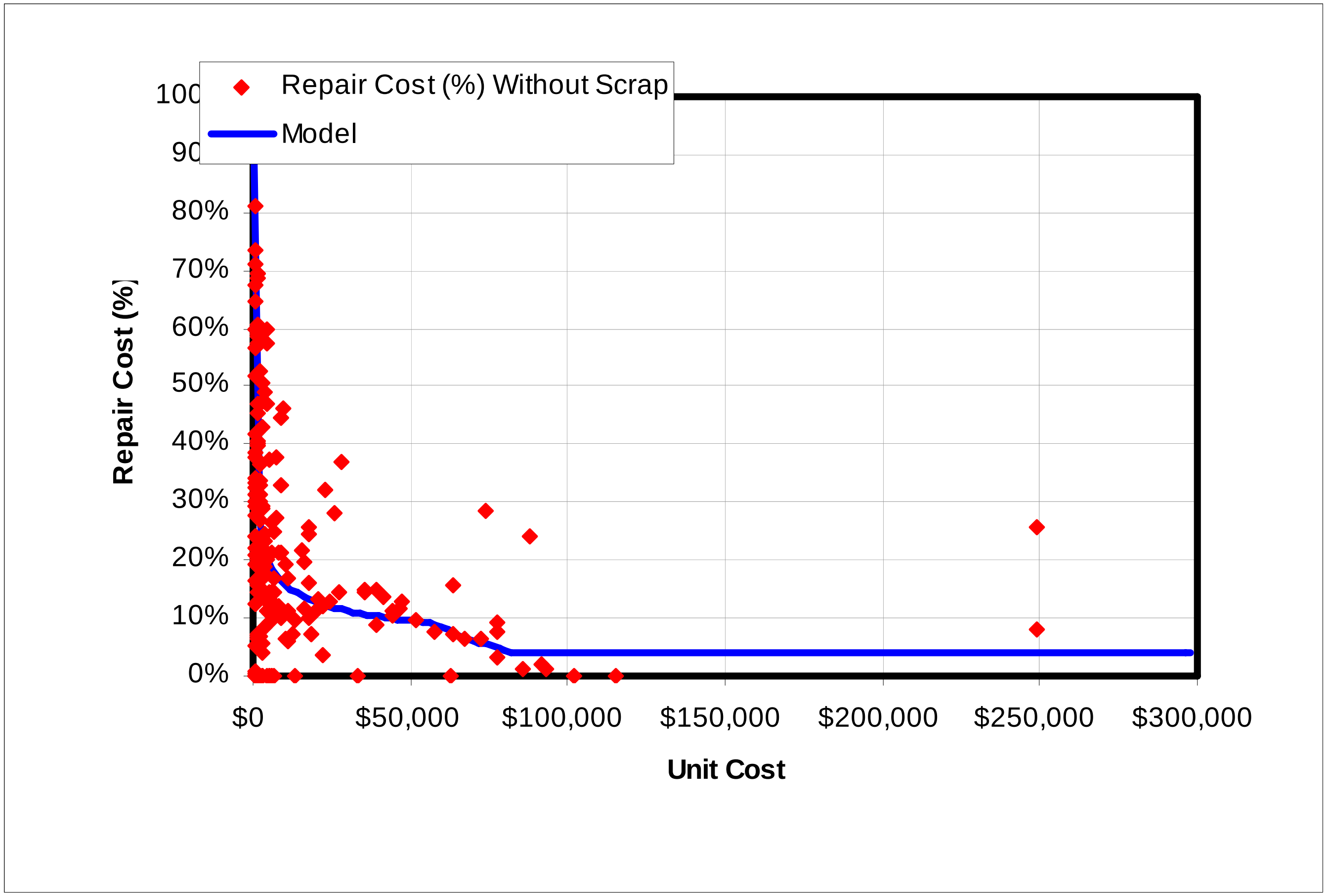
Determining the Average Repair Cost

- Repair Cost data only exists for ~ 26% of total consumable parts
  - Determine the <u>Average Repair Costs</u> for Repairable Parts listed in CDRL A004*
  - Determine <u>Average Scrap Rates</u> for Repairable Parts listed in CDRL A004
- For remaining consumables (~74%):
  - Use Parametric Models developed from CDRL A004 data

* CDRL A004 Repairable Items Repair Cost Summary)

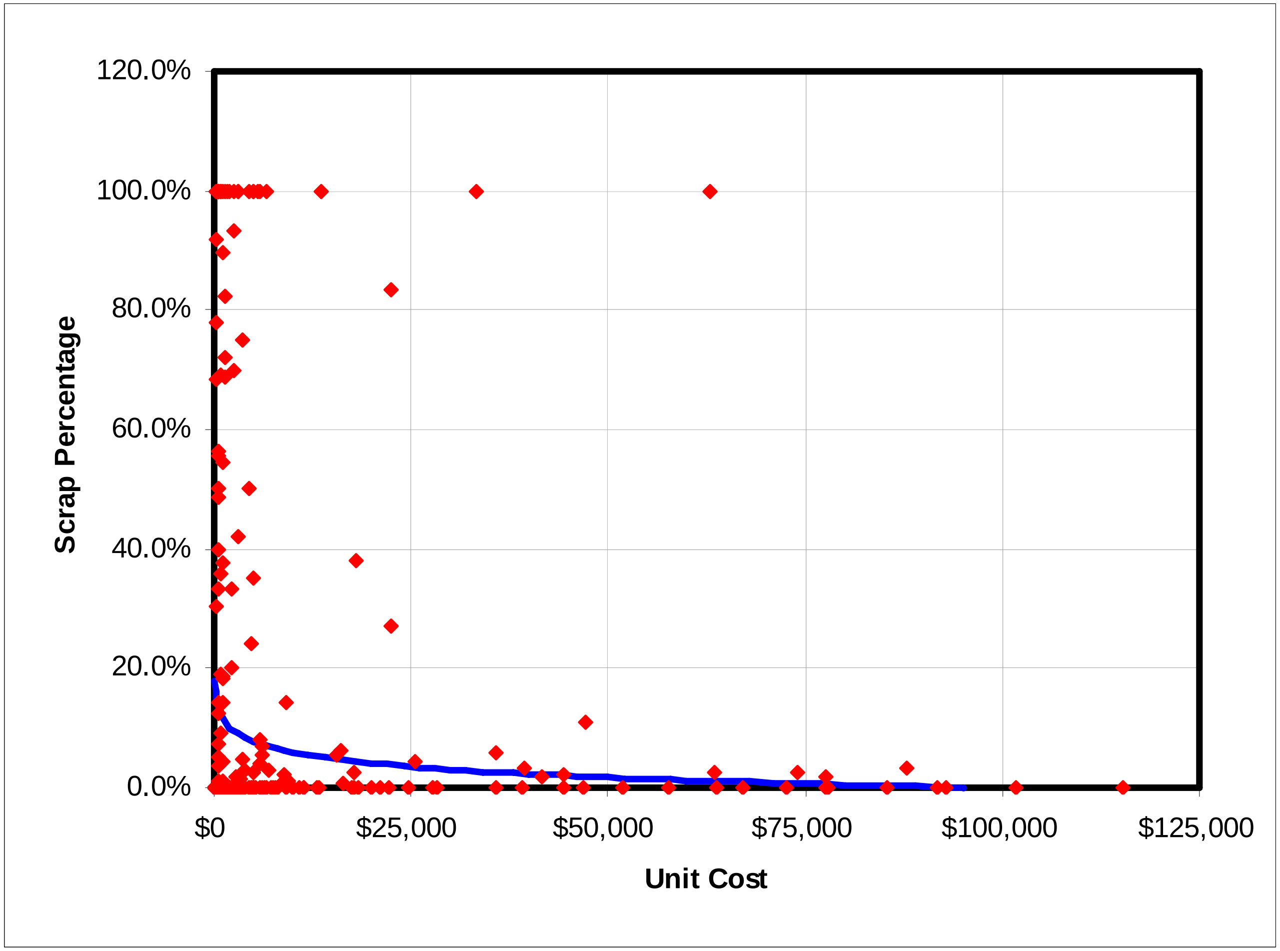
Repair Costs Parametric Model

- Data from CDRL A004
- Uncertainty for parts or assemblies costing more than $50k
- Repair of Powerpack set to 30%
- Did not factor in warranty items



Scrap Rate Parametric Model

- Model Used For Parts not in CDRL A004
- High statistical variance for some parts due to small sample size
- 100% data points ignored in the model



Total Vehicle Mileage

$$\text{Cost Per Mile} = \frac{\text{Labor + Replacement Parts + Part Repair}}{\text{Total Vehicle Mileage}}$$

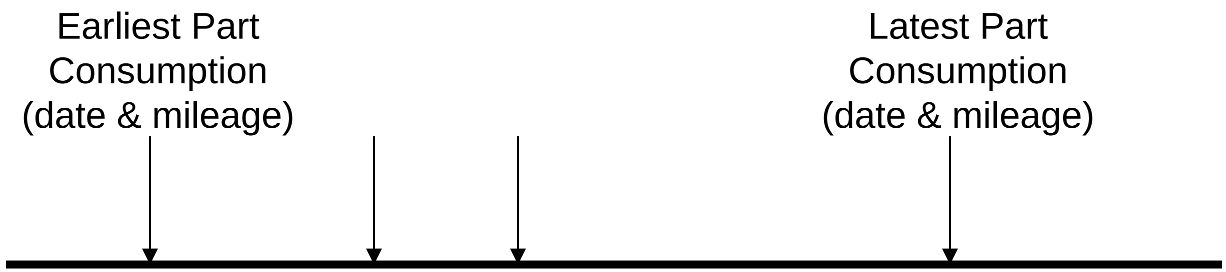
Vehicle Mileage : Does not exist for all vehicles

Questionable accuracy

- Extreme values discarded.
- Miles/day calculated for every vehicle in the database
- Average miles/day from the database assumed to apply to all Brigade vehicles

Estimating Miles Per Day

For each vehicle

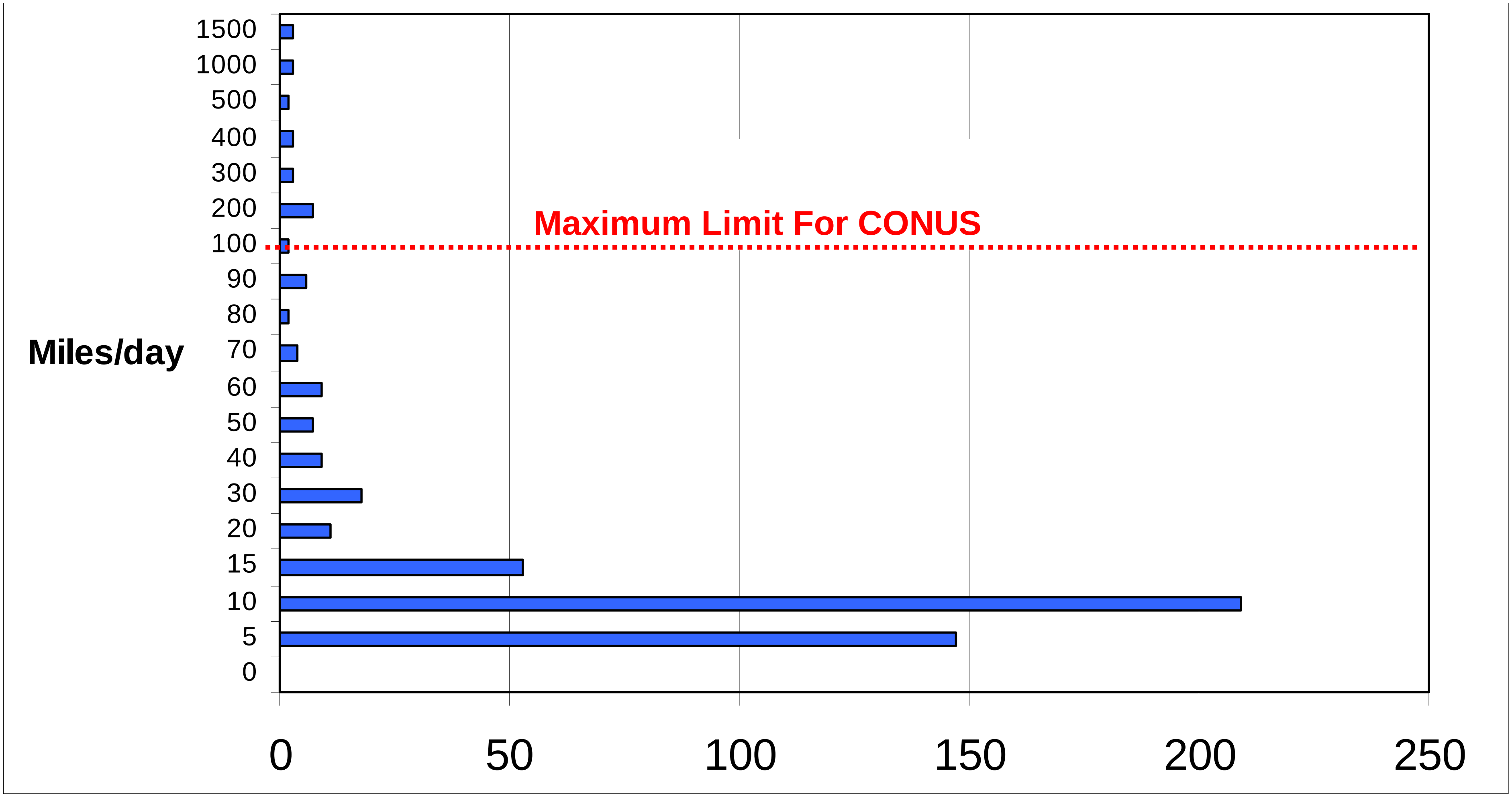


Vehicle miles per day ~ $(\text{Miles}_L - \text{Miles}_E)/(\text{Day}_L - \text{Day}_E)$

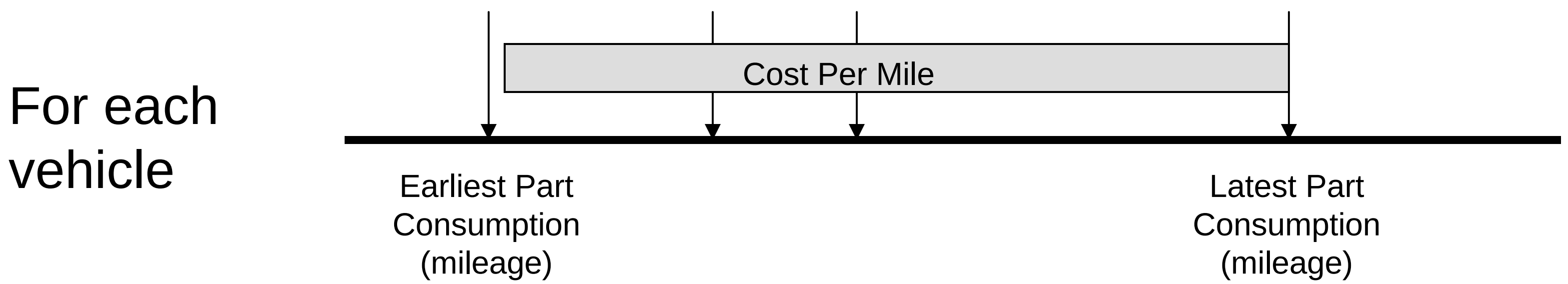
- Miles/day computed for each vehicle
- Downtime not factored into the estimation.

Vehicle Miles Per Day From A003

(CONUS)

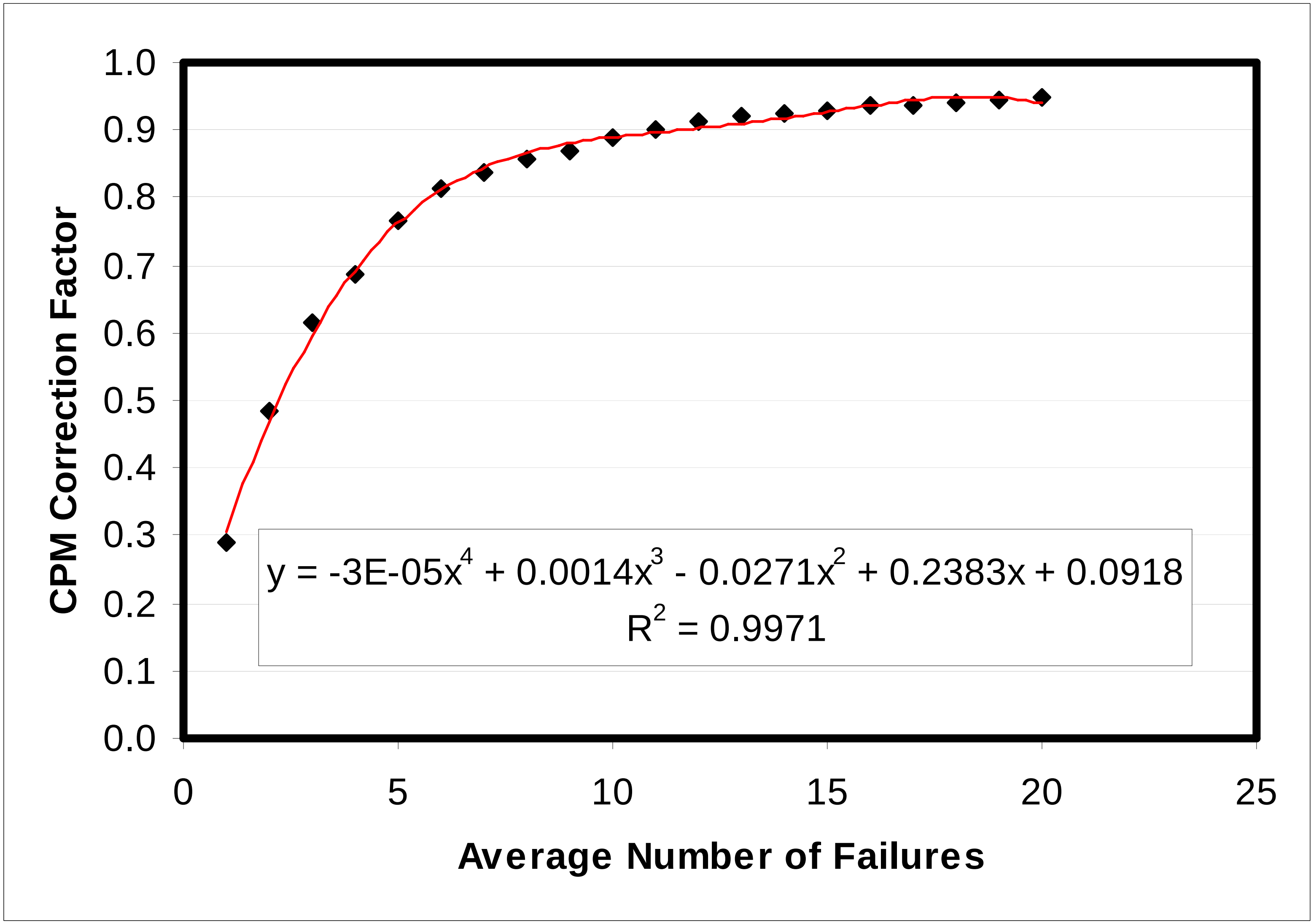


Estimating the Repair Cost per Mile



- Above computation over estimates cost/mile because it doesn't include any mileage before the first or after the last part consumption
- The error is a function of the number of failures (i.e., as the failures increase, the error decreases)
- Numerical simulations were performed to develop a correction factor to be applied to the computed repair costs per mile

Correction Factor for the Estimated Repair Cost Per Mile



CONUS Cost Per Mile

- **CPM based on vehicles with:**
  - Maximum total miles < 5,000
  - Maximum Miles/Day < 100
- **Models:**
  - Parametric Repair Cost Model
  - Parametric Scrap Rate Model
  - Cost per Mile Correction
- **Assumptions**
  - 300 Strykers Per Brigade (all operational)
  - Power Pack repair = 30% unit cost

CONUS Cost/Mile

ICLS Labor, Replacement Parts, Part Repair

Vehicle Type	No. Vehicles	Repair Cost in Computation	Total Mileage in Computation	Spares/ Repair Parts Cost/mile	Miles Per Day	Total CPM
ICV	345	$1,581,641	218,138	$7.25	7.56	$9.41
MCV	101	$279,921	22,504	$12.44	5.39	$14.59
ATGM	43	$172,499	20,200	$8.54	6.67	$10.69
ESV	29	$395,797	28,970	$13.66	9.51	$15.82
FSV	33	$165,540	18,558	$8.92	6.90	$11.08
MEV	35	$66,682	17,405	$3.83	6.16	$5.99
RV	161	$559,520	110,313	$5.07	7.32	$7.23
All vehicles	**747**	**$3,221,599**	**436,088**	**$7.39**	7.31	$13.30

Assumptions: Each vehicle < 5k total miles, < 100 miles/day average, 30% repair cost for Power Pack

Deployed Cost Per Mile

- **CPM based on vehicles with:**
  - Maximum total miles < 20,000
  - Maximum Miles/Day < 400
- **Models:**
  - Parametric Repair Cost Model
  - Parametric Scrap Rate Model
  - Cost per Mile Correction
- **Assumptions**
  - 300 Strykers Per Brigade (all operational)
  - Power Pack repair = 30% unit cost

Deployed Cost/Mile

ICLS Labor, Replacement Parts, Part Repair

Vehicle Type	No. Vehicles	Repair Cost in Computation	Total Mileage in Computation	Spares/ Repair Parts Cost/mile	Miles Per Day	Total CPM
ICV	315	$8,225,102	1,108,756	$7.42	36.93	$9.57
MCV	70	$765,983	120,708	$6.35	22.08	$8.50
ATGM	52	$1,393,062	218,260	$6.38	43.50	$8.54
ESV	28	$587,658	134,119	$4.38	64.33	$6.54
FSV	27	$486,028	95,890	$5.07	36.94	$7.22
MEV	38	$223,414	79,945	$2.79	25.70	$4.95
RV	126	$2,303,741	317,632	$7.25	31.72	$9.41
All vehicles	**656**	**$13,984,989**	**2,075,310**	**$6.74**	35.59	$7.95

- Model assumes $4.73M per brigade
- Higher miles/day for Deployed vehicles results in lower Total Cost Per Mile

Assumptions: Each vehicle < 20k total miles, < 400 miles/day average, 30% repair cost for Power Pack

Sensitivity Analysis
(CONUS)

- Using an Overall Average Repair Cost (based on CDRL A004) Instead of the Parametric Models drops the CPM by 2%
- Increasing the limit on Miles Per Day (from 100 to 300) drops the CPM by 3%
- Increasing the limit on Maximum Miles (from 5,000 to 10,000) drops the CPM by 4%

Challenges

- Validity of comparisons
- Baseline assumptions
- Missing Data
- Quality of data

Recommendations

- Continue Research
  - Complete Stryker analysis
- Feedback from sponsor
- Feedback from community
- Determine path ahead
- Develop methodology for conducting suitability studies on other systems
- Look at other programs for comparison
  - Other services, other types of systems

Insight: Operability Testing for High Availability Systems

Edward Beck
Computer Sciences Corporation

NDIA National Test & Evaluation Conference
March 12-15, 2007

CSC
EXPERIENCE. RESULTS.

Agenda

- Background
- System Management Overview
- Case Study: Insight
- The Benefits of Insight

The Aegis Weapons System

- Aegis is the world's premier naval surface defense system. It is capable of simultaneous operation defending against air, surface, subsurface and ballistic missile threats.

- There have been 7 major releases, known as baselines, in the nearly 4 decade history of Aegis.

- Recent baselines have focused on re-engineering the weapons system to take advantage of commercially available off-the-shelf (COTS) operating environments (OE).

EXPERIENCE. RESULTS.

A Migration to Open Architecture

Proprietary Systems

Manufactured hardware and developed software

Open Technology

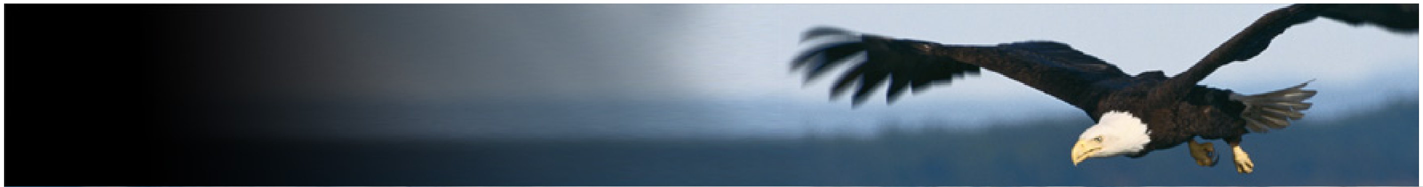
Emphasis on COTS hardware and software integration

Computing System Management functions have become more complex with the adoption of COTS technology

Open Technology

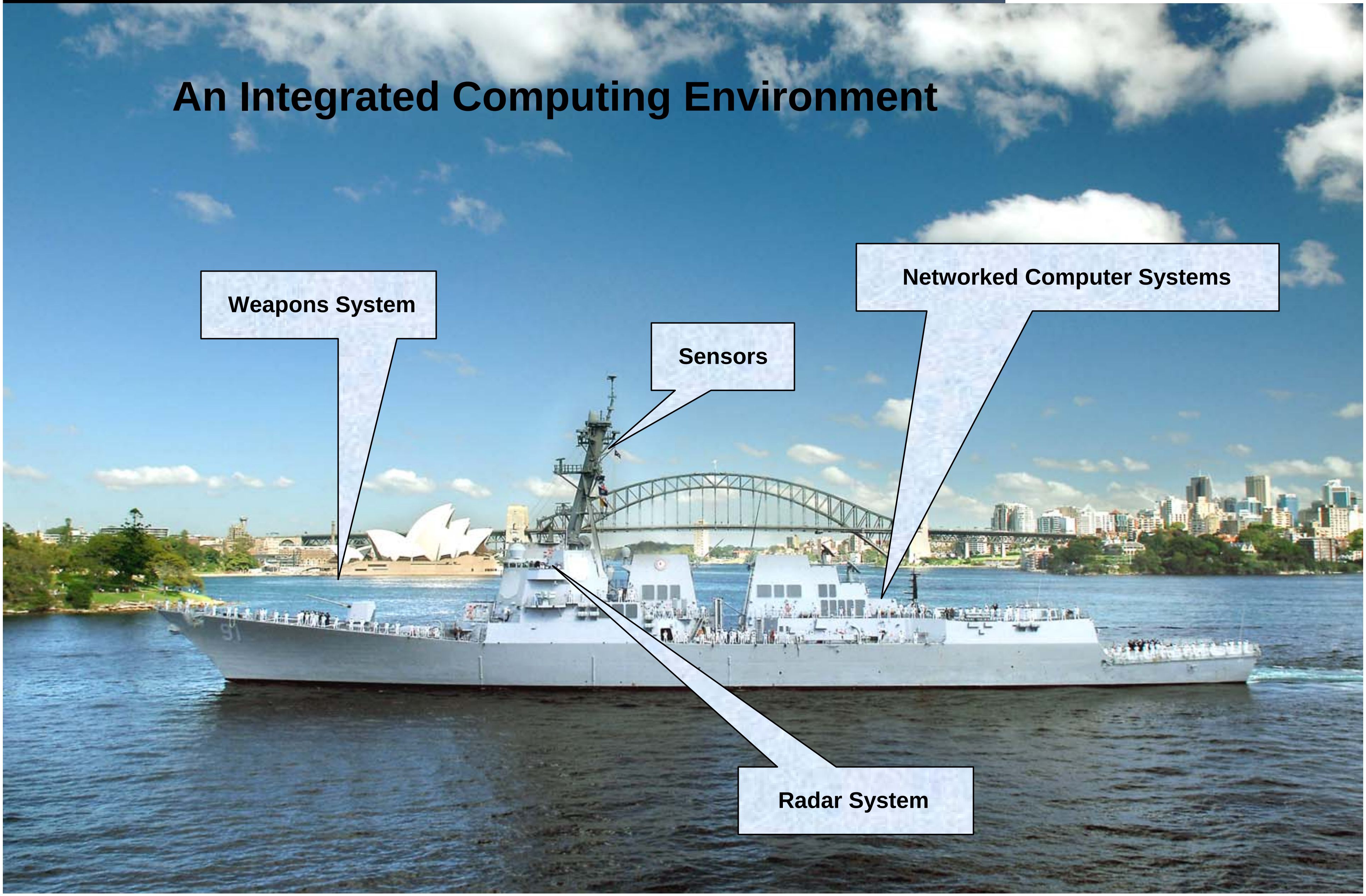
- An Aegis ship not much different from a large-scale commercial data center.

- The weapons system is comprised of a standard operating environment with unique components not seen in commercial architectures.



CSC
EXPERIENCE. RESULTS.

An Integrated Computing Environment



CSC EXPERIENCE. RESULTS.

System Management Overview

Application Management

- Manage where applications are running
- Manage runtime state of the applications
- Manage recovery and reconfiguration
- Assess health status of the applications

Equipment Management

- Node/Server Management
  - **Diagnostics**
  - **Performance Monitoring**
- Network Management
- Asset Management
  - **Validation and Verification**
  - **Software Distribution**

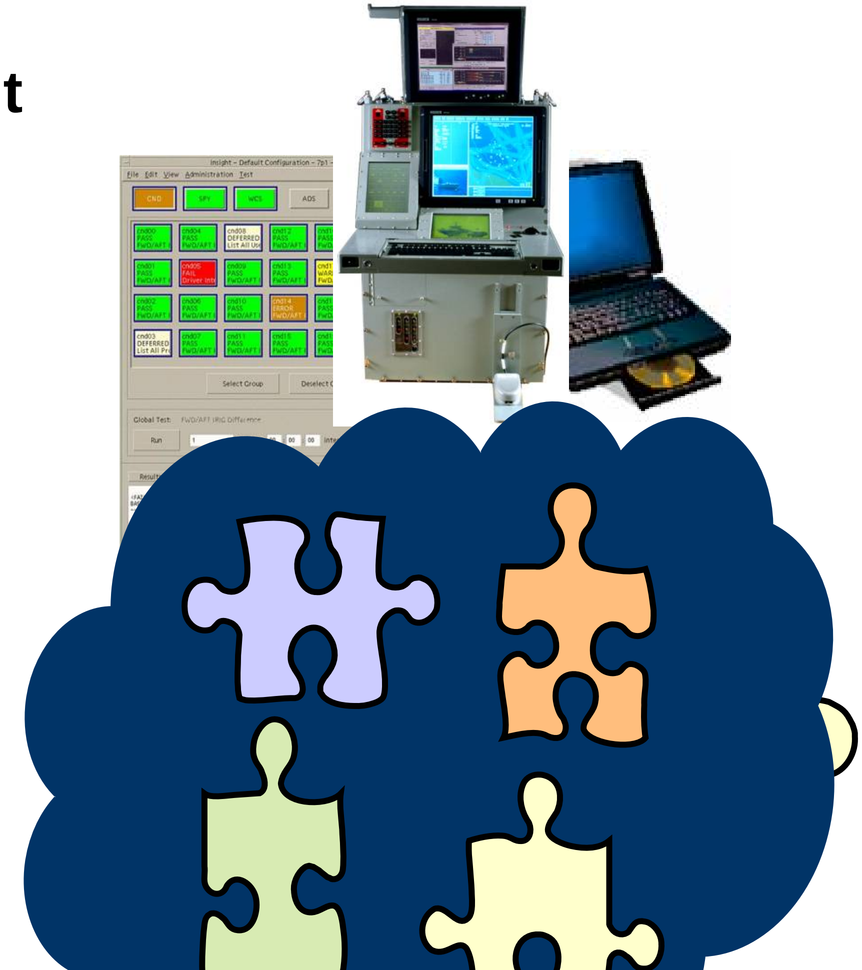
Fault Detection / Fault Isolation

Root Cause Analysis

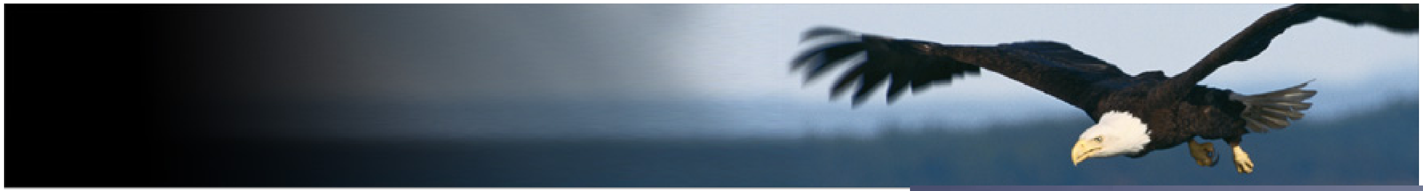
CSC
EXPERIENCE. RESULTS.

Aegis System Management

- In the current baselines, System Management for the Aegis Weapons System is comprised of multiple components.
- Each component exists as a standalone entity.
- Together, they interoperate to provide an end-to-end solution for Operational Readiness Assessment of the combat system.

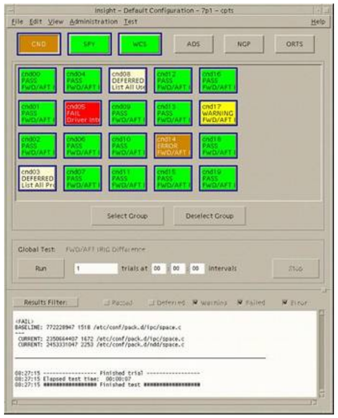


Insight is a key component for managing the operating environment of the Aegis Weapons System



EXPERIENCE. RESULTS.

Case Study: Insight



What is Insight?

- An integrated computing system management toolkit.

- It is a highly configurable suite of open source, commercially available, and developed tools that perform system management functions across the enterprise.
  - Hardware and software diagnostics
  - Performance monitoring
  - Network management
  - System control
  - Validation and verification

CSC
EXPERIENCE. RESULTS.

The Catalyst For Insight

1970 - 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2005

1969
Aegis begins. Baselines 1 through 5 are deployed with a proprietary operating environment.

1994
Baseline 6 signals the emergence of COTS processors to augment the legacy computer suite.

1999
Baseline 7 signals the emergence of an all-COTS computer suite.

2000
Deployment of Baseline 6 is plagued by schedule delays. Ad-hoc tools with weak fault detection and inefficient fault isolation.

2001
CSC produced a White Paper to address the need for a well defined system management strategy on the COTS baselines. Design and development of Insight begins.

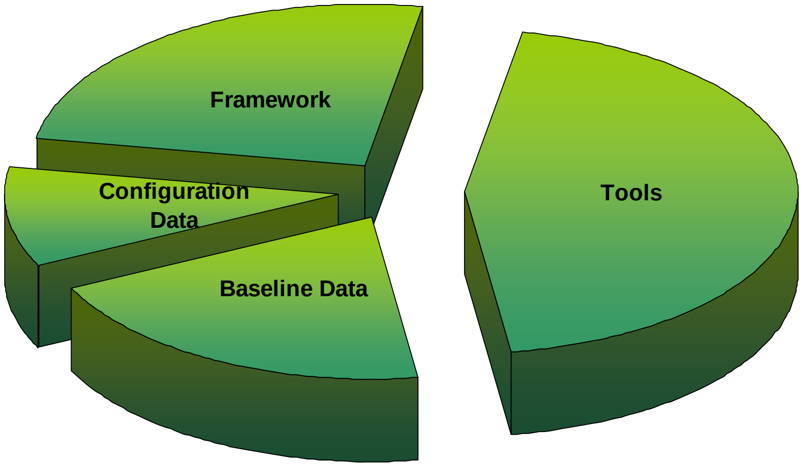
2002
Initial version of Insight deployed to local data centers.

2003 - Current
Insight is deployed to Baseline 7 for use in shipyard integration activities and shipboard Operational Readiness Assessment.

CSC EXPERIENCE. RESULTS.

Insight Component Architecture

- Framework
  - Graphical User Interface, Network Services, and Remote Agents
- Tools
  - Configurable collection of “best-of-breed” products and utilities to perform system management functions
- Configuration Data
  - Easily tailors Insight to the needs of the open architecture enterprise being managed
- Baseline Data
  - Repository of expected OE configuration state information

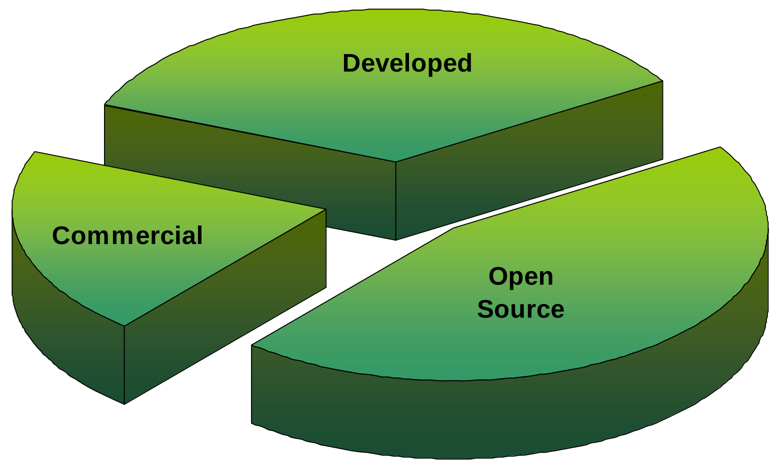


EXPERIENCE. RESULTS.

Extensive Use Of Open Source Technology

- Over 40% of Insight is comprised of Open Source software
  - Permits selection of cost effective, best-of-breed solutions
  - Reduces development time
  - Leverages intellectual resources from the world wide development community

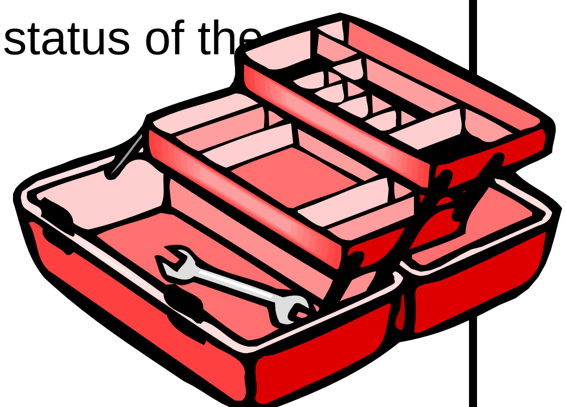
Functional Composition



Capitalizing on Open Source saved approximately $1M in development costs

Application Management

- Manage where applications are running
- Manage runtime state of the applications
- Manage recovery and reconfiguration
- Assess health status of the applications



Insight's Toolkit

Equipment Management

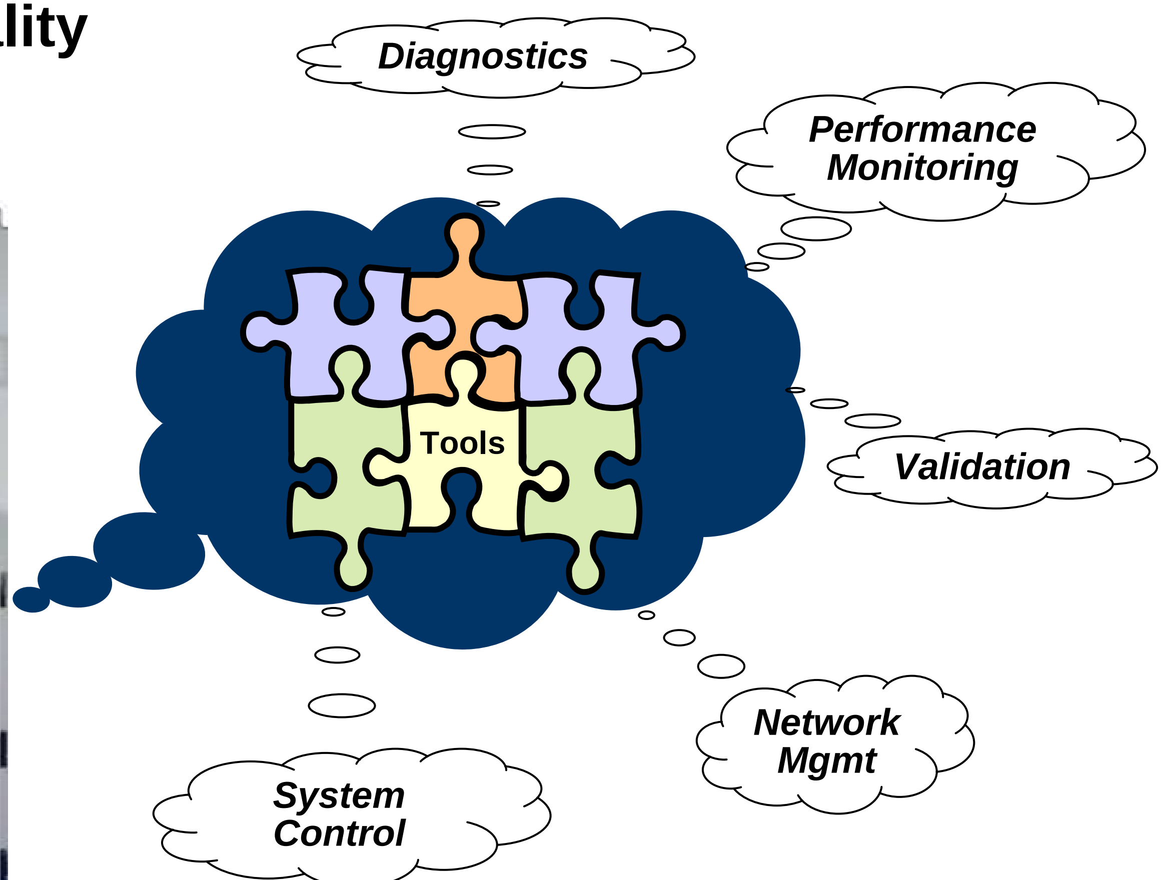
- Node/Server Management
  - **Diagnostics**
  - **Performance Monitoring**
- Network Management
- Asset Management
  - **Validation and Verification**
  - **Software Distribution**

Fault Detection / Fault Isolation

Root Cause Analysis

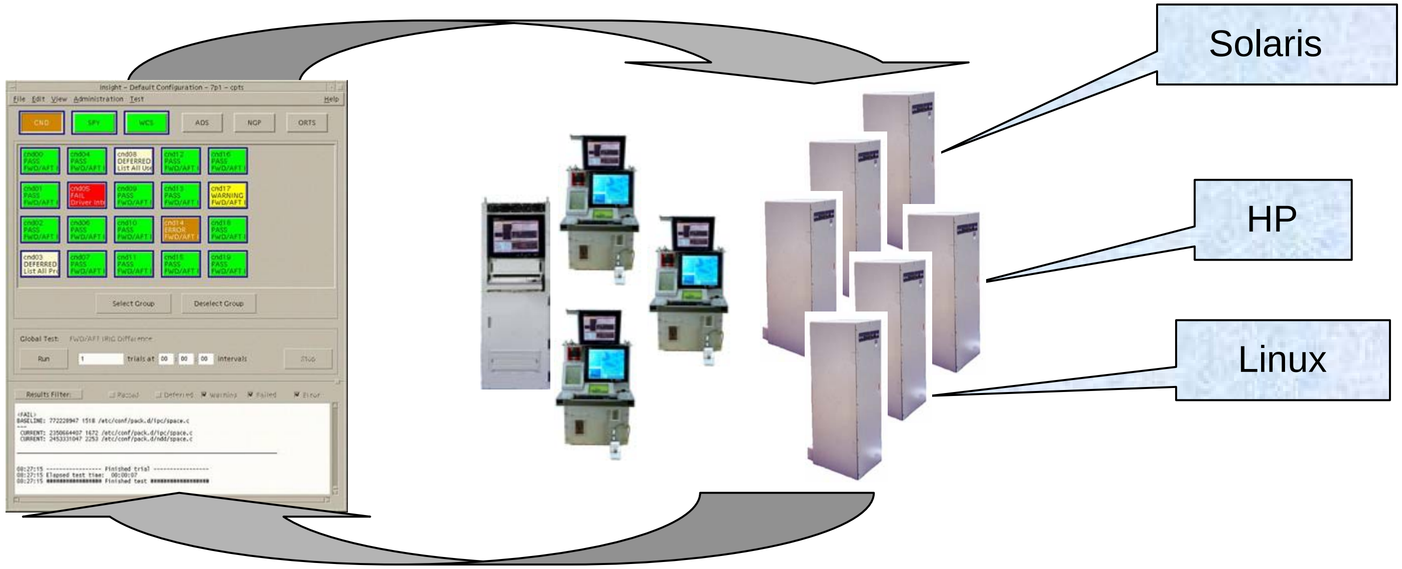
Insight Functionality

- On-demand Testing
- Runtime Monitoring
- Interactive Control



Consistent Interface for Disparate Tools

- Standardizes test execution
- Hides tool variability from the user
- Provides common results



Insight standardizes the execution and results of each tool, regardless of platform or tool origin

Hardware and Software Diagnostics

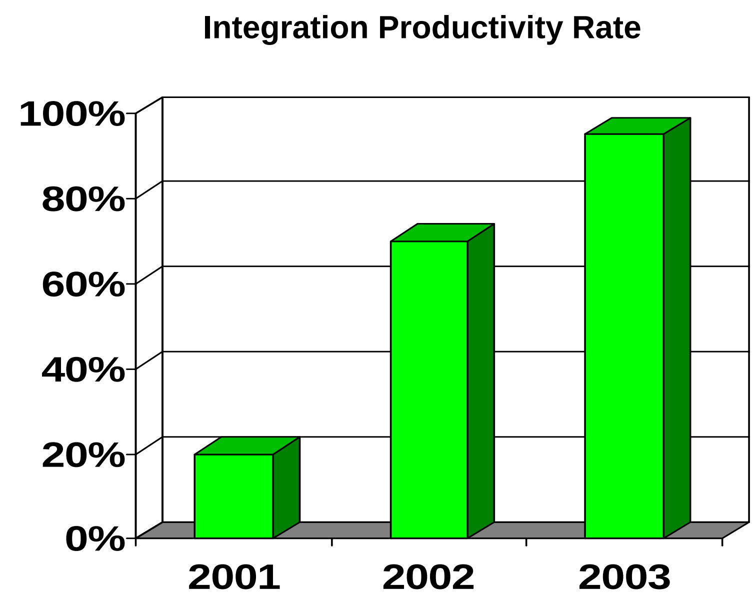
- Fault Detection / Fault Isolation (FD/FI)

- Assess the operational state of hardware and software components
  - NTDS Devices
  - I/O Boards
  - Specialized Processors
  - Tactical Interfaces
  - Middleware Components

CSC
EXPERIENCE. RESULTS.

Increased Productivity

The availability of Insight has increased the productivity rate to over 90% by providing rapid identification of operating environment issues.

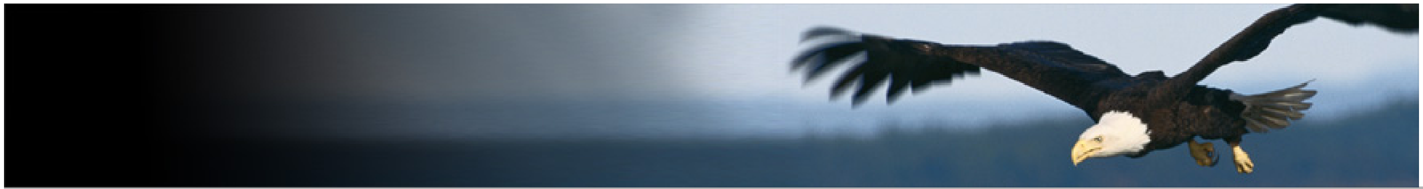


Rapid Resolution = Increased Productivity = Significant Savings

Performance Monitoring

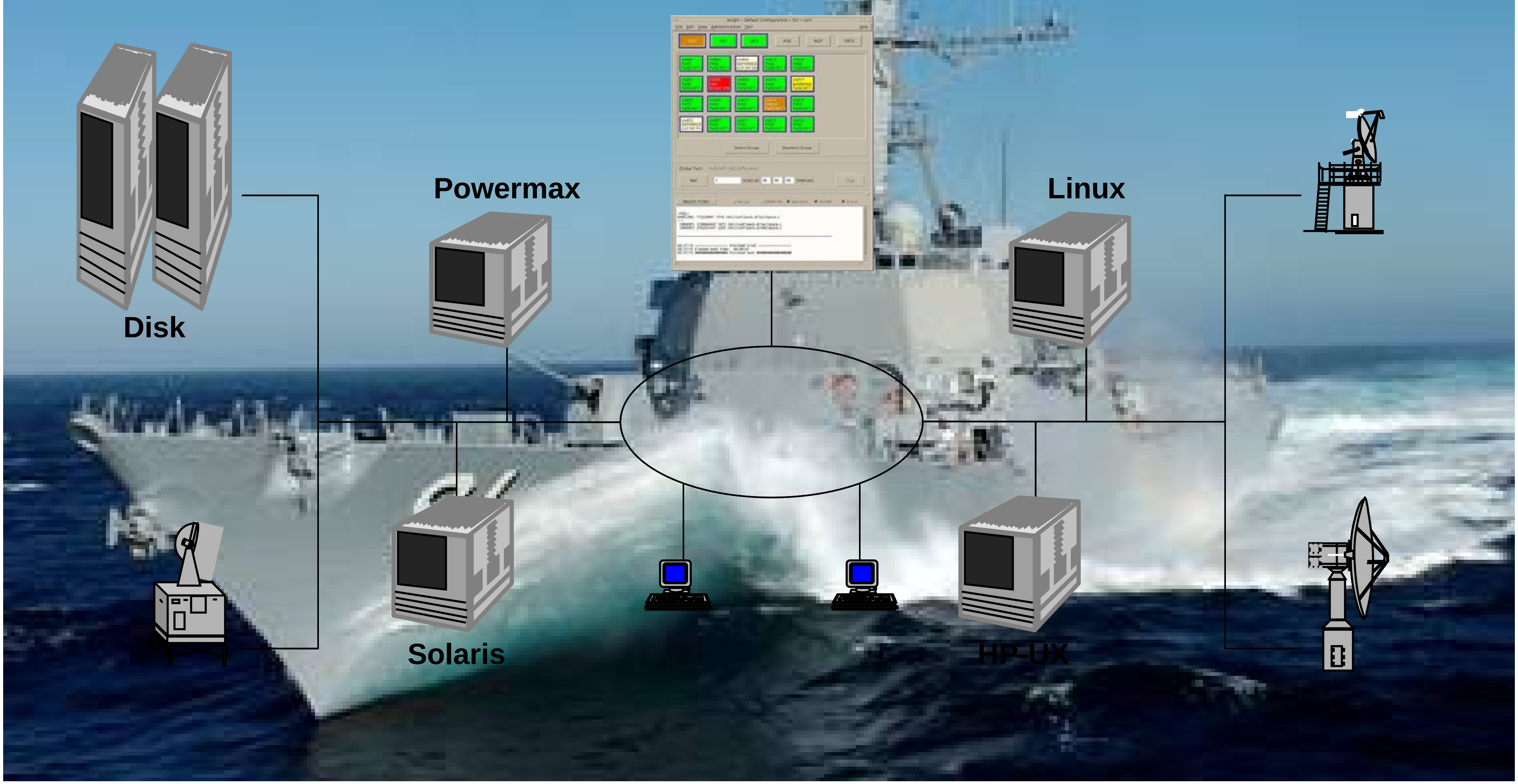
- Assess infrastructure performance under operational conditions
  - CPU utilization
  - Memory utilization
  - Process activities
  - Disk usage
  - I/O activity
  - Kernel-level trace

- Data is represented in real-time as well as archived for statistical representation



CSC
EXPERIENCE. RESULTS.

Insight assesses operational readiness of combat system components from a single console



Validation and Verification

- System Operability Test

- Checks a number of Operating Environment configuration parameters to determine overall system operability
  - Configured Devices
  - Filesystem Integrity
  - Kernel Tunables
  - Network Tunables
  - Installed Packages
  - OS Version and Patches
  - Firmware

- Ensures that the current state of a host’s OE is consistent with established baseline data

CSC EXPERIENCE. RESULTS.

Automated Validation of the Operating Environment

Integration and Test Facility

=

Deployed System

Insight ensures that the deployed configuration is identical to the staged environment

Automated System Validation: Months to Minutes

There are over 6000 configuration parameters on each node that are optimized for the application

Insight provides accurate validation for the entire computer suite within 3 minutes

Manual validation of the configuration for the entire computer suite would take nearly 4 staff months

Automated validation provides complete confidence in the deployed configuration and saves significant taxpayer dollars

Network Management

- Assess health status and performance of the local area network
  - LAN operability
  - Routes
  - Network utilization

System Control

- Manage the run-time state of the tactical applications
  - System Initialization
  - Shutdown
  - Reboot

EXPERIENCE. RESULTS.

Run-time state of the system can be monitored and controlled from a single console

Concept of Operations

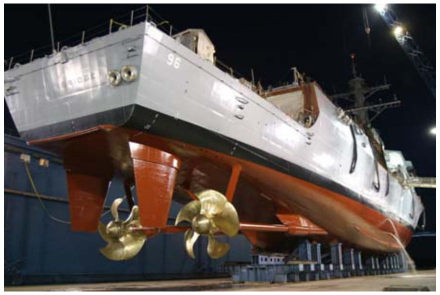
- Insight is used throughout the life-cycle of the combat system.

Development Data Center

Validation of the build environment

Staging and Test Facility

Shipyard Integration

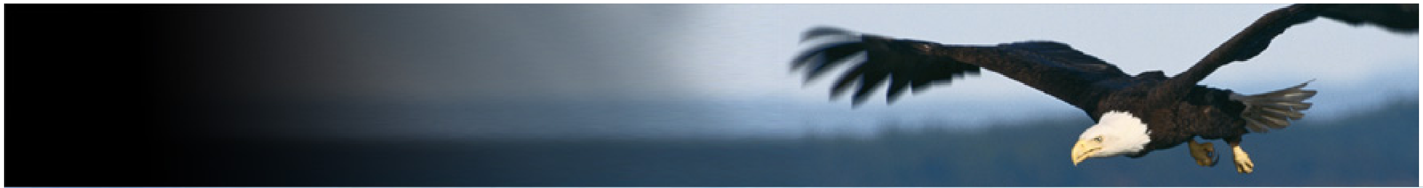


System validation, diagnostics, operability tests

Deployed Systems

Runtime status monitoring, operability tests, diagnostics

Insight has become standard operating procedure for Aegis



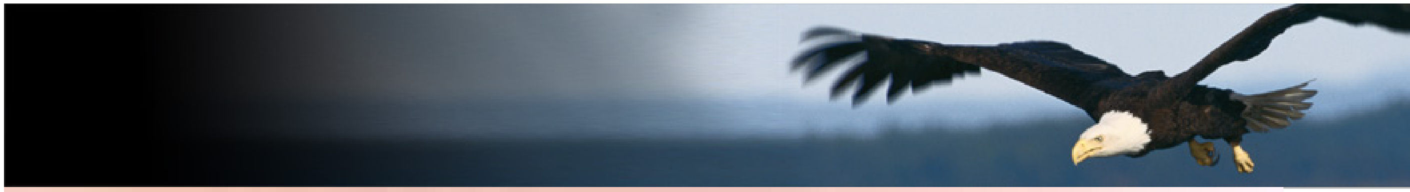
CSC
EXPERIENCE. RESULTS.

Safety Checks

Insight's safety agent prevents intrusive functions during tactical operations.

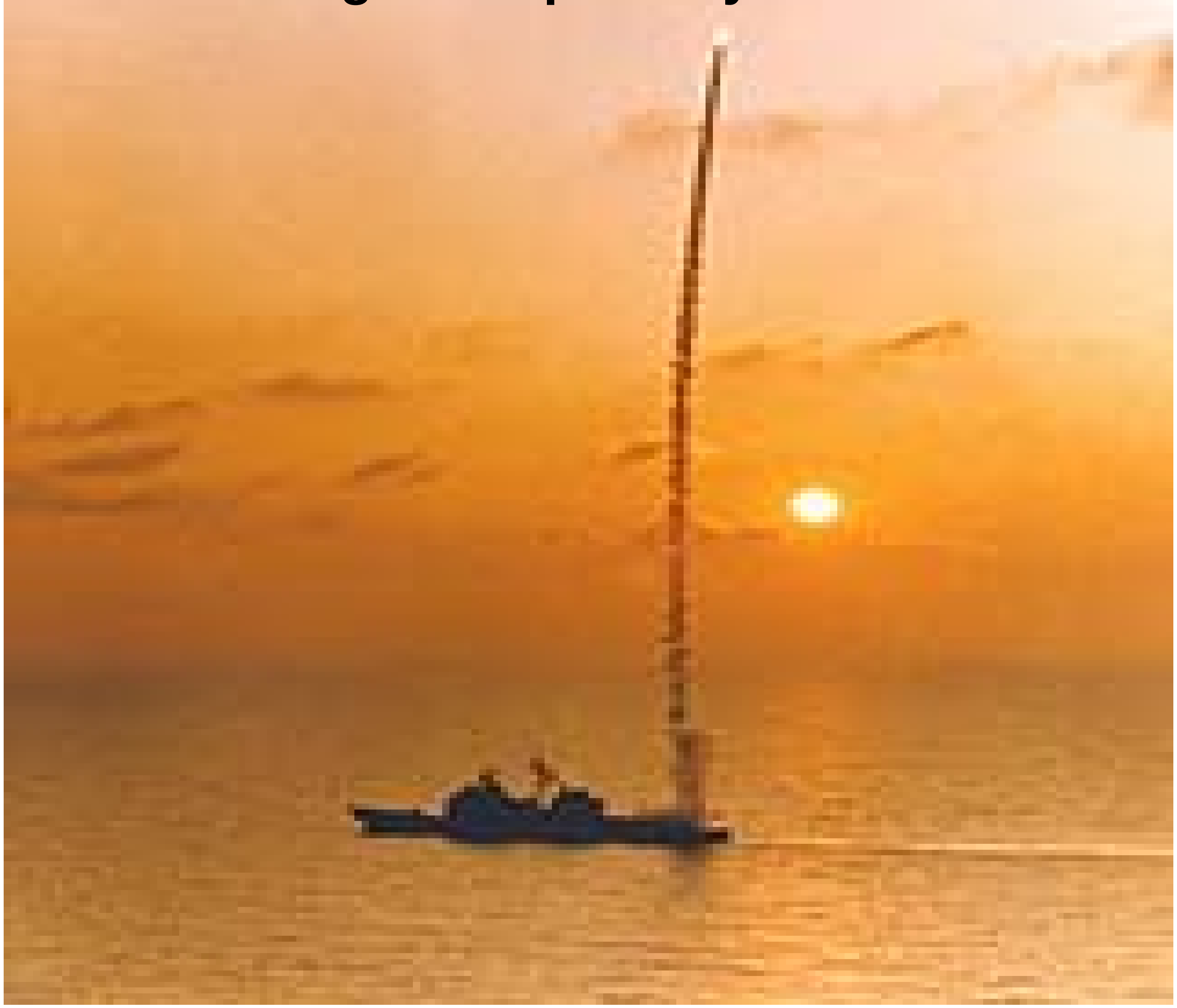
EXPERIENCE. RESULTS.

The Benefits of Insight



EXPERIENCE. RESULTS.

A Vital Maintenance Solution for the Aegis Weapons System

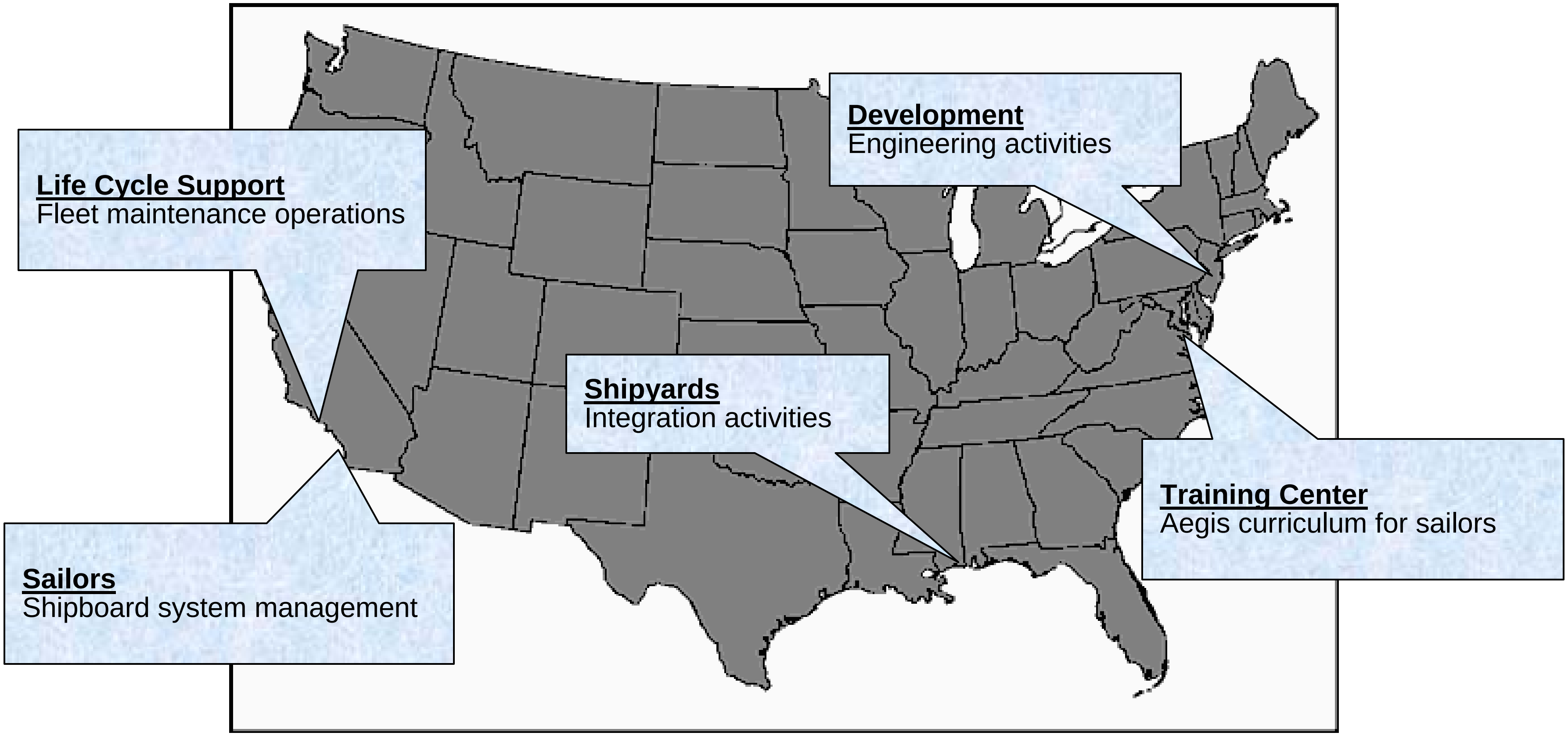


Proprietary systems had an available toolset.

Insight provides a robust toolset for COTS systems.

EXPERIENCE. RESULTS.

Applying Insight to Support Various Activities



Insight is a key component for Aegis System Management

Enhanced Operational Readiness

Dispatching engineers to troubleshoot shipboard issues:

$75K

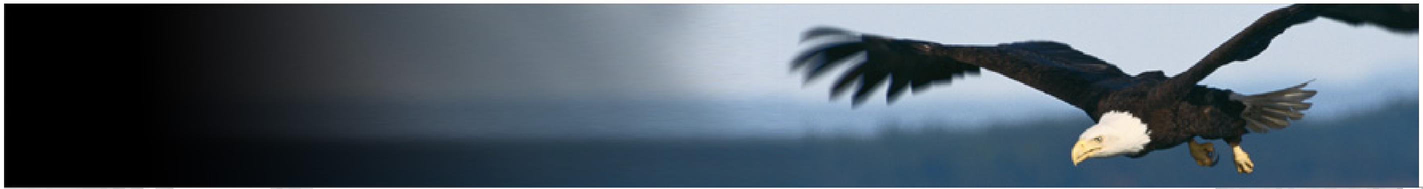
Delaying a missile test due to system instability:

$1M

Meeting deployment schedules and increasing credibility with your customer:

Priceless

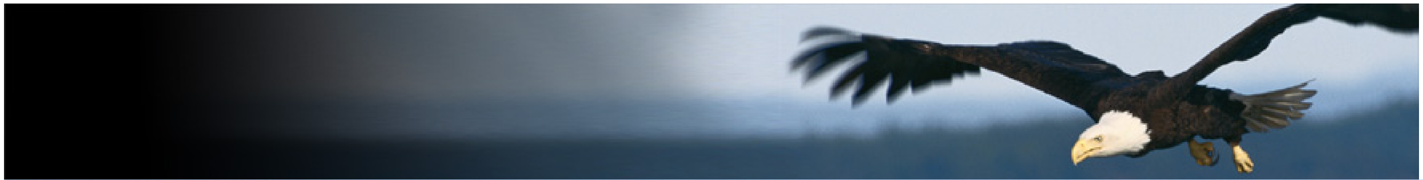
Insight is playing a vital role ensuring that ships are deployed on schedule for immediate use in various theatres of operation



CSC EXPERIENCE. RESULTS.

"Innovation: Delivered"

- **Deployed for 3 ½ years**
- **Multiple Baselines**
- **Domestic and Foreign Test Sites**
- **Domestic and Foreign War Ships**
- **Certified for Tactical Operations**



EXPERIENCE. RESULTS.

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LMI
GOVERNMENT CONSULTING

THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

Tradespace Analysis for Capabilities, Effectiveness, and Resources (TRACER)

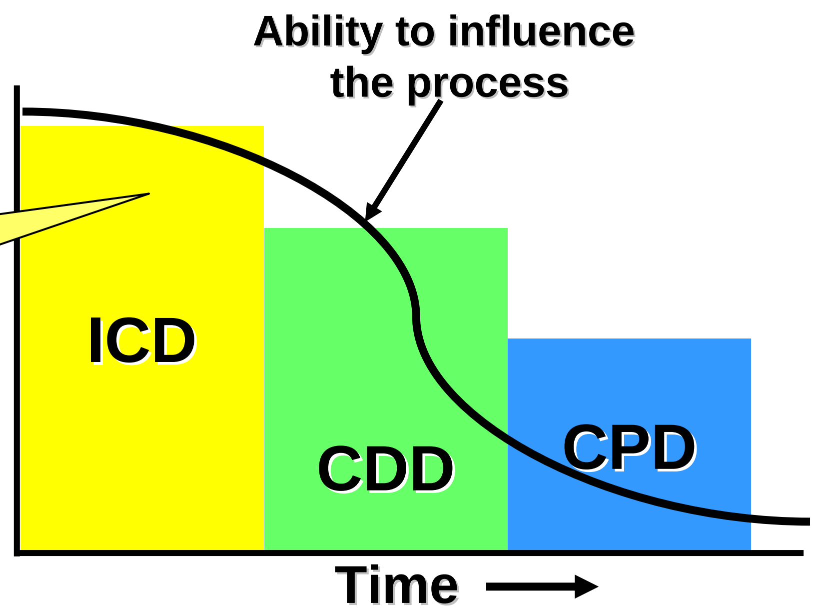
ACQUISITION • FACILITIES & ASSET MANAGEMENT • FINANCIAL MANAGEMENT • INFORMATION & TECHNOLOGY • LOGISTICS • ORGANIZATIONS & HUMAN CAPITAL

Agenda

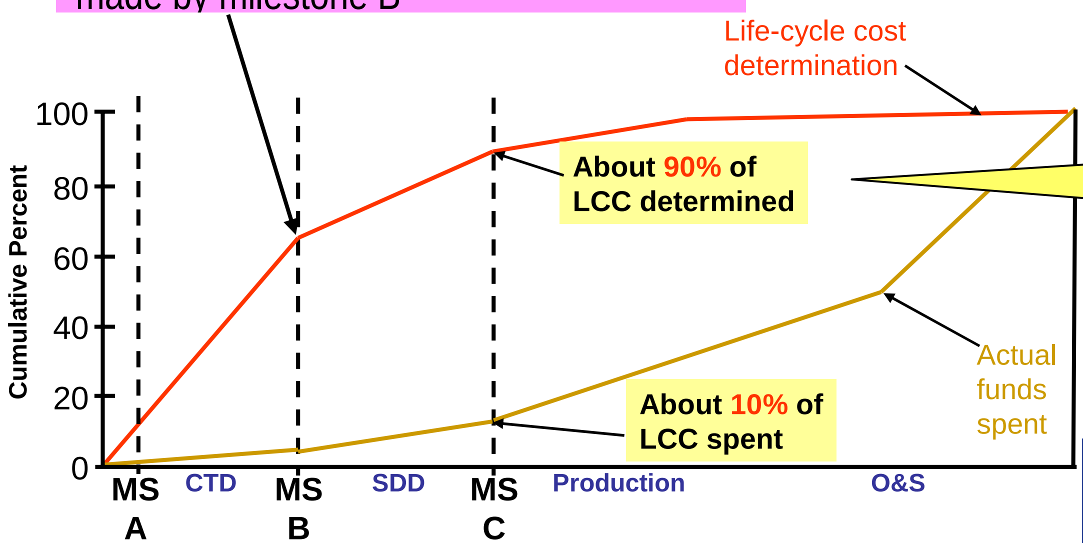
- The Case for Integrated Analysis
- What is TRACER?
- Example TRACER Analyses
- The Way Ahead

Why Early Tradeoff Analysis?

Do tradeoff analyses while you have the ability to influence the design…



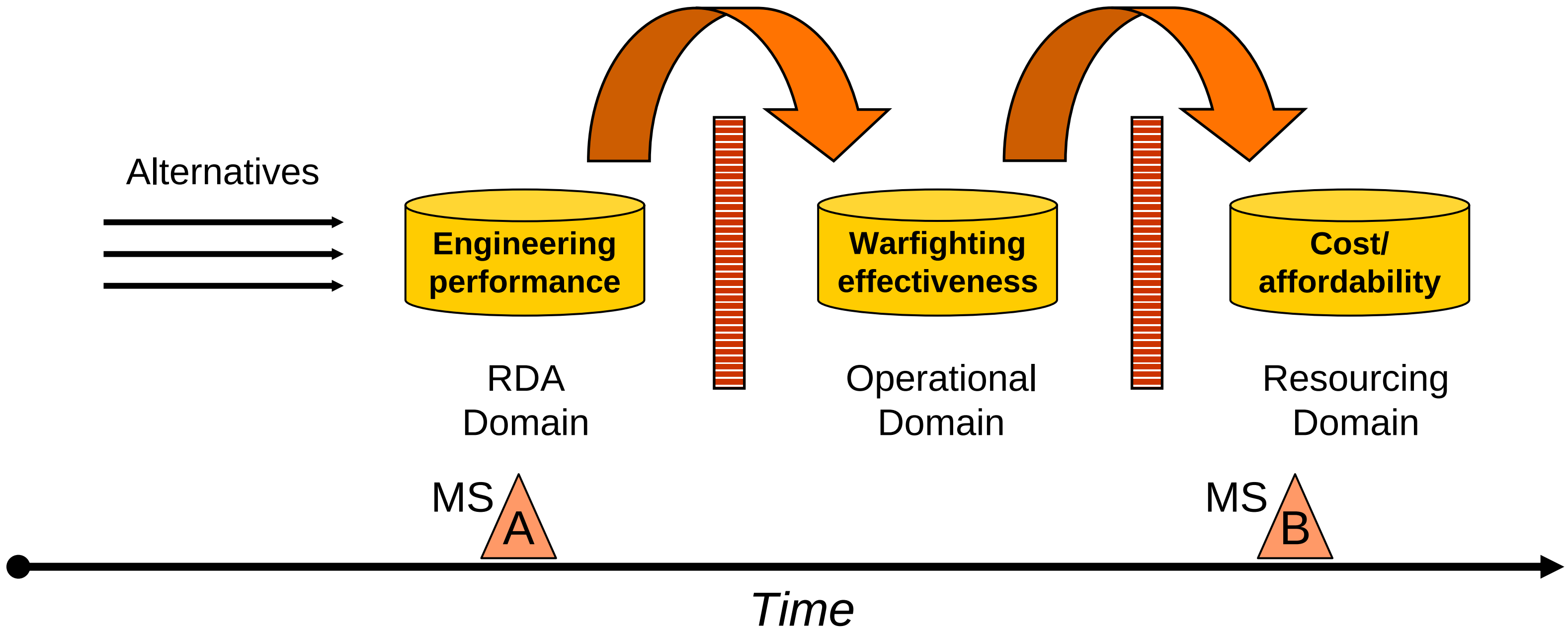
Decisions that determine 70% of LCC are made by milestone B



…and your influence has the greatest impact!

Traditional Alternatives Analysis Approach

- Evaluates limited number of alternatives
- Stovepipes reduce incentives to share insights across domains
- Takes lots of time and resources to evaluate each alternative
- Does not facilitate finding optimal solutions

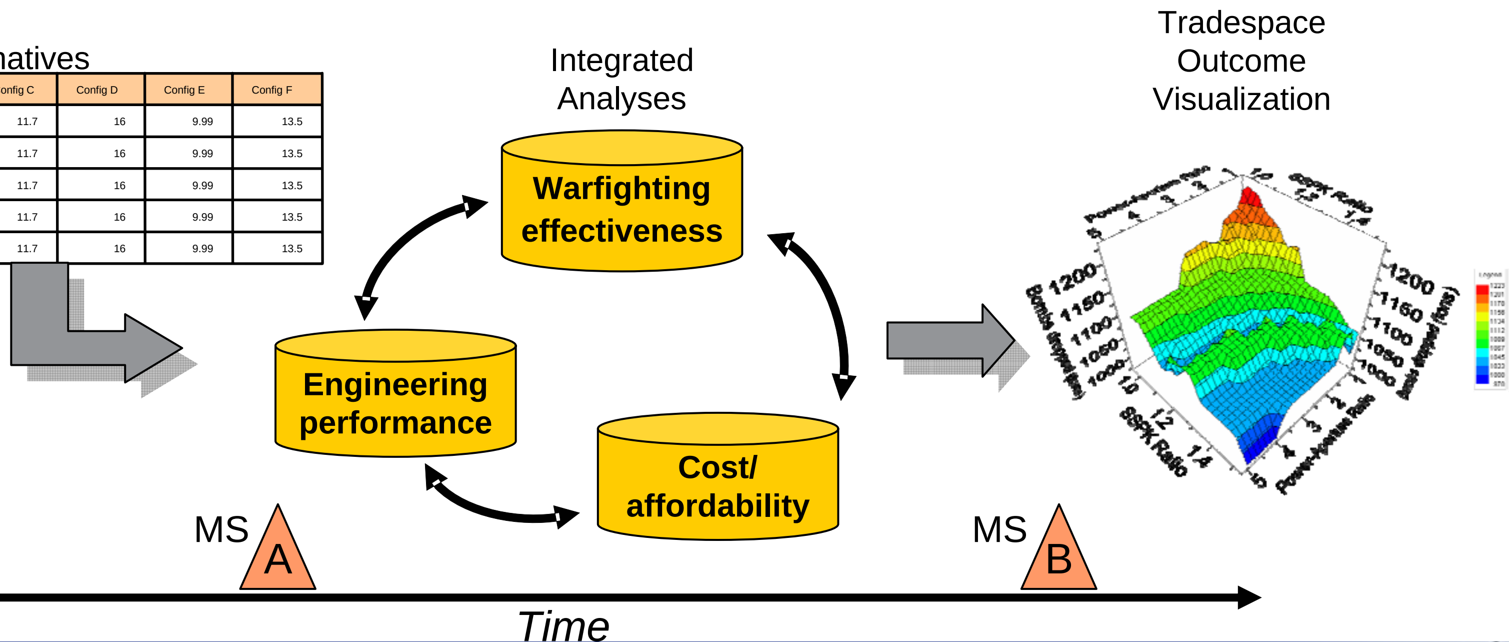


Integrated Alternatives Analysis Approach

- Exposes the entire tradespace
- Integration enables insights to be gained through the synergy of the domains
- Greatly reduces the time and resources for comprehensive evaluation
- Embedded analytical tools facilitate finding optimum solutions

Alternatives

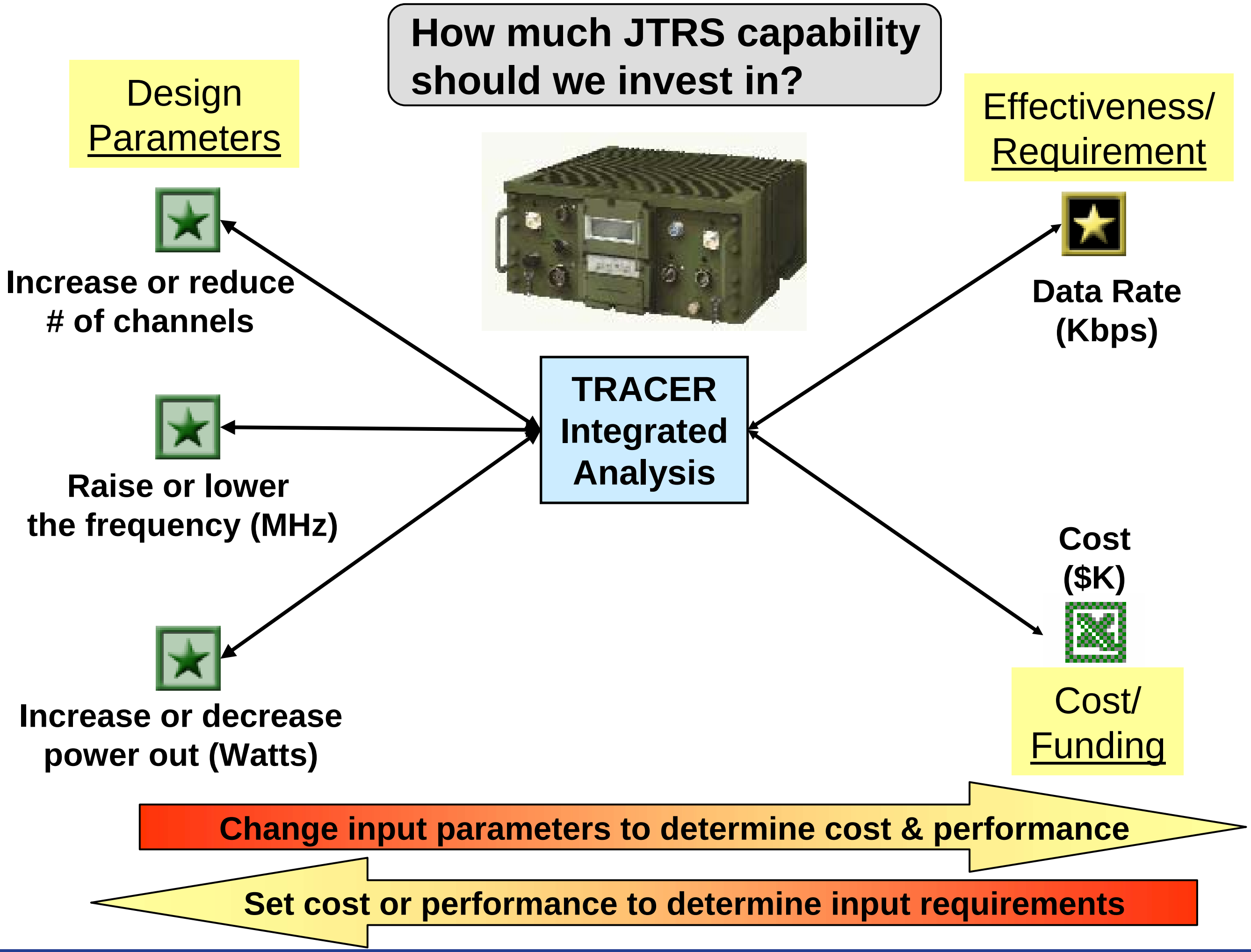
	Config A	Config B	Config C	Config D	Config E	Config F
Criteria 1	12.2	10.2	11.7	16	9.99	13.5
Criteria 2	12.2	10.2	11.7	16	9.99	13.5
Criteria 3	12.2	10.2	11.7	16	9.99	13.5
Criteria 4	12.2	10.2	11.7	16	9.99	13.5
Criteria 5	12.2	10.2	11.7	16	9.99	13.5



What is TRACER?

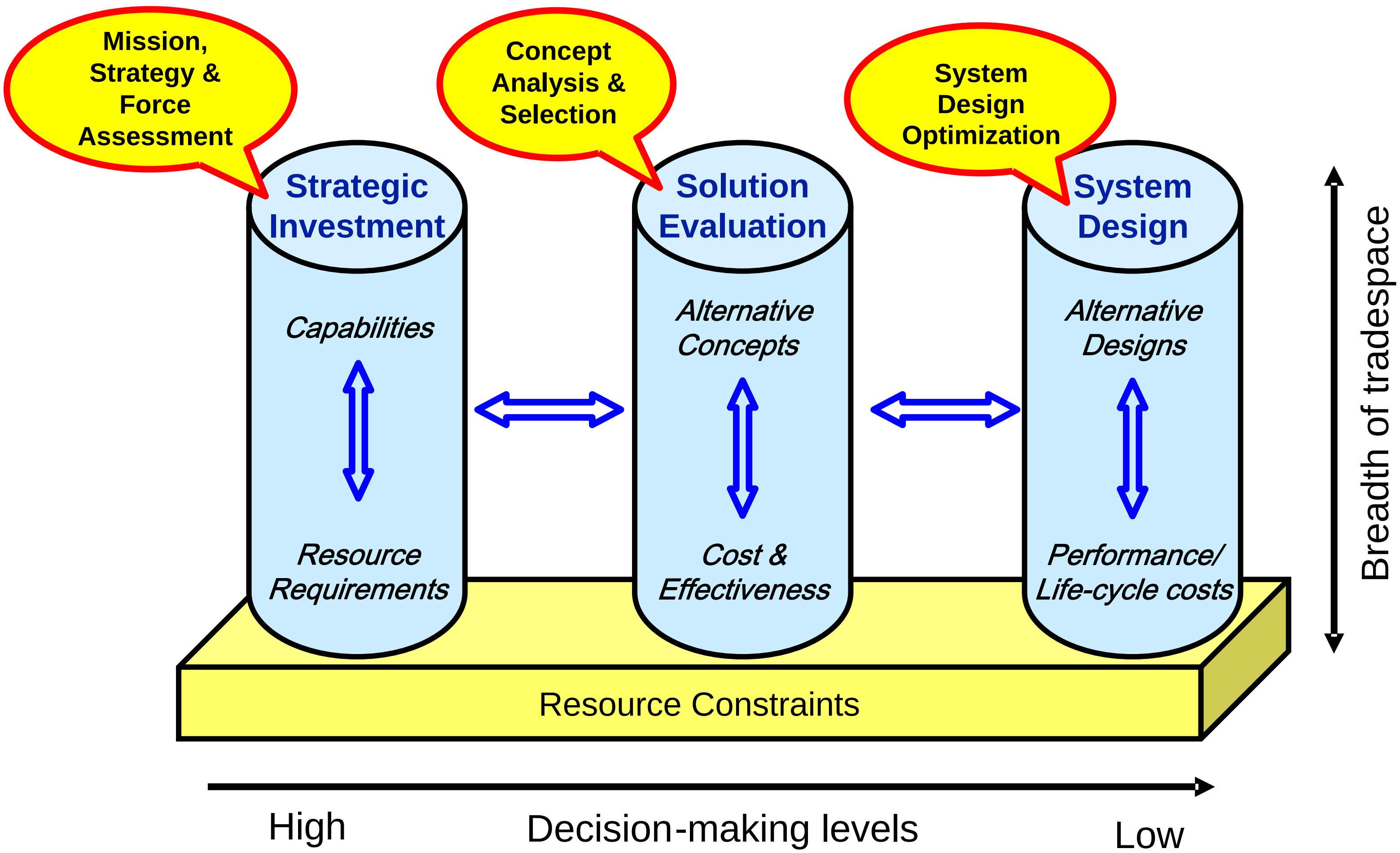
- TRACER facilitates the application of systems engineering to acquisition analysis
- TRACER implements a holistic investment analysis approach in an analytical framework that:
  - simultaneously addresses multiple evaluation disciplines including warfighting effectiveness, performance, and cost
  - can be applied at different levels in the resource analysis environment: strategic, operational/tactical, and acquisition
  - aims to explore the widest possible solution space, informing the alternatives analysis with cost tradeoffs
- TRACER enables analysts and decision makers to do Cost As an Independent Variable (CAIV) analyses
- TRACER methodology uses modeling and simulation to reduce the time, resources, and risk associated with investment decisions

Example: JTRS Tradeoff Analysis



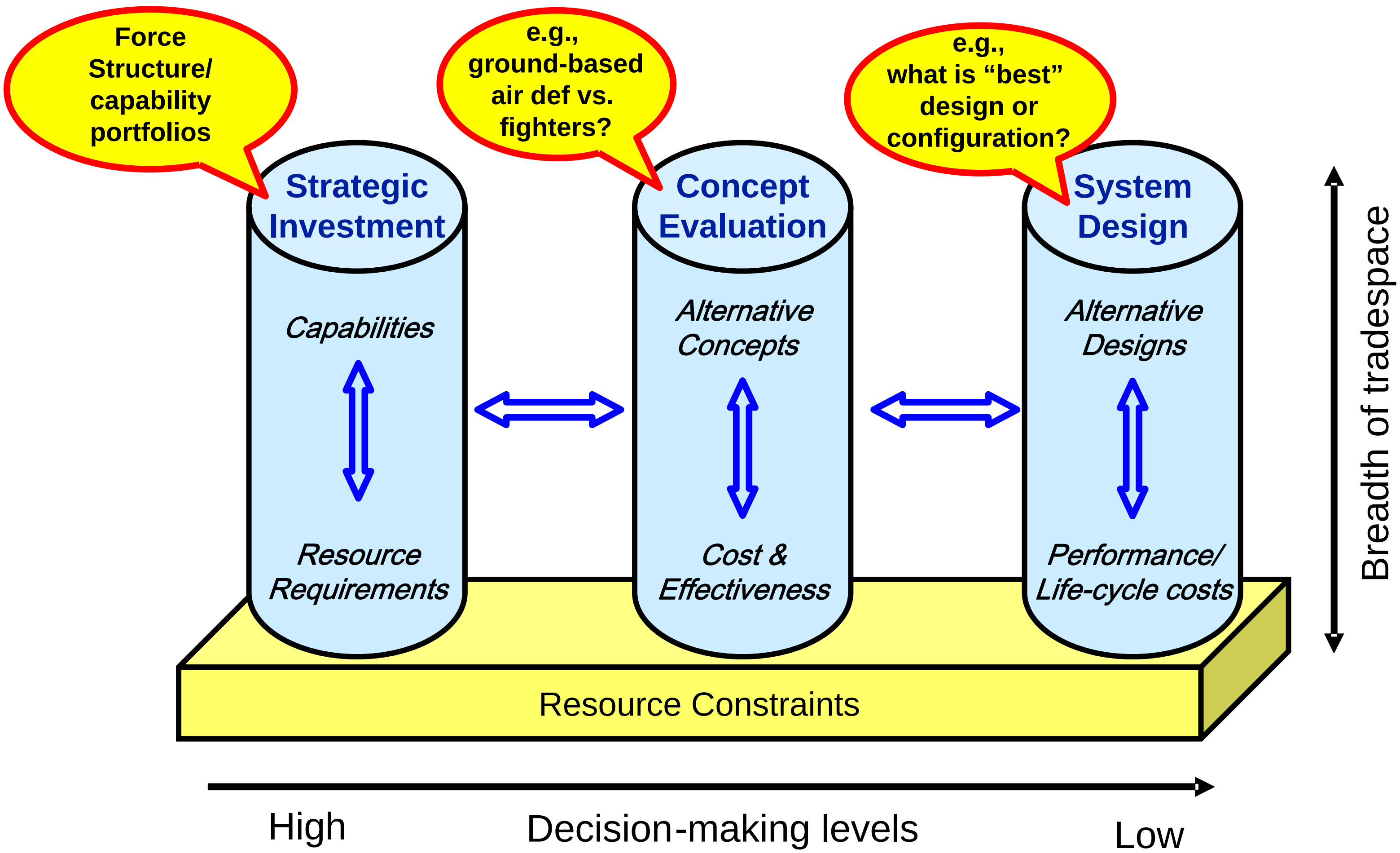
Multi-dimensional Tradespace

To maximize decision tradespace, optimize both within *and* across dimensions



Multi-dimensional Optimization Problem

To maximize decision tradespace, optimize both within *and* across dimensions



Operational Example:

Air-to-Air Campaign

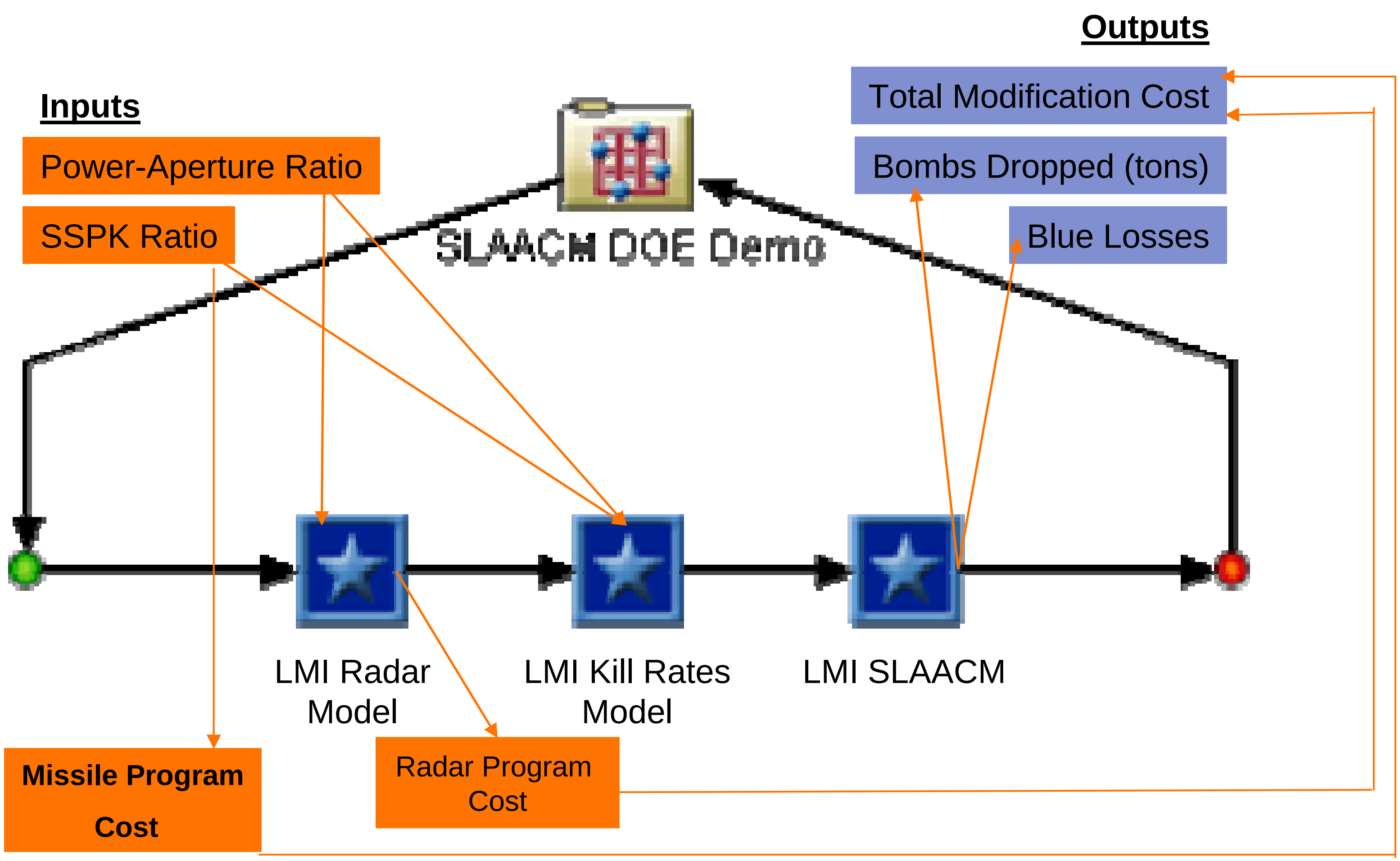
Air-to-air Campaign Analysis

- Requirement: Blue fighter fleet must defeat an optimal assault from a mix of 792 Red aircraft, allowing ***no more than 1,100 tons of bombs dropped*** by "leakers," with 80% confidence that there are ***no more than 45 Blue losses***.
- Current fighter fails: 1,200 tons dropped, 56 Blue losses
- Approach 1: Improve airframe and propulsion (at cost of $12B)
  - Result? Success! 1,067 tons dropped, 42 losses

But, how else might the requirement be met?

- Approach 2: Improve radar (cost and outcome are functions of improvement)
- Approach 3: Improve missile (cost and outcome are functions of improvement)

Air-to-air Campaign Analysis Framework



SLAACM = Stochastic Air Campaign Model

Air-to-air Analysis Design of Experiments (DOE)

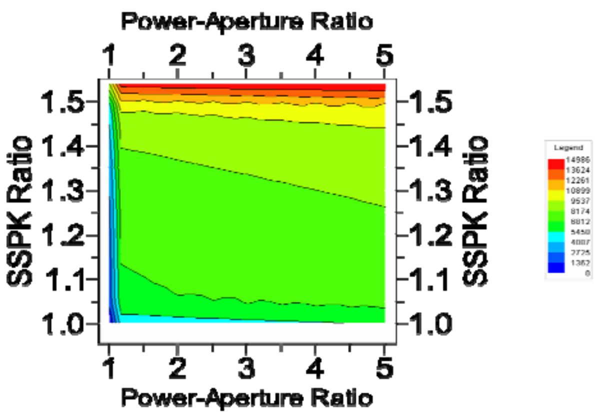
- Choose 492 randomly distributed values for Power-Aperture ratio and SSPK ratio
- P-A ratio values range between 1.0 and 5.0
- SSPK ratio (improvement over current performance level) values range between 1.0 and 1.537

TRACER Analysis

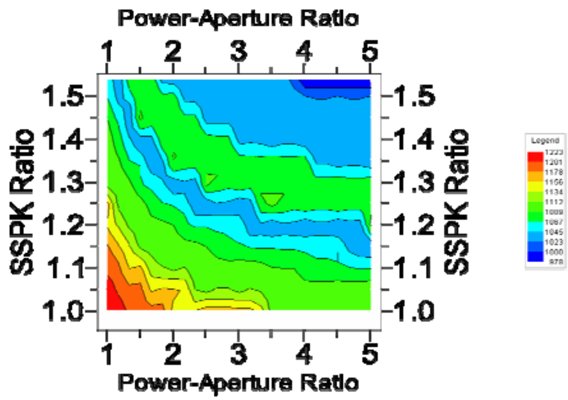
- Run all 492 cases and graph results
- Measure outcomes in blue losses and bombs dropped, and total modification/acquisition costs
- Identify best solution among the feasible outcomes

Air-to-air DOE Results

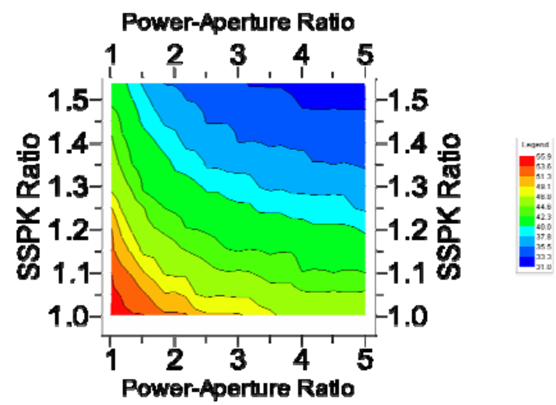
Modification Cost

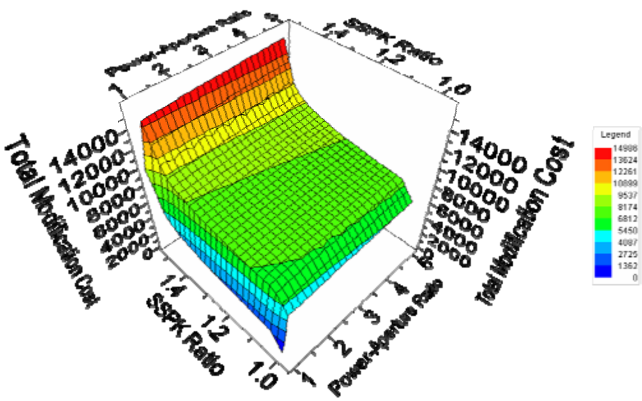


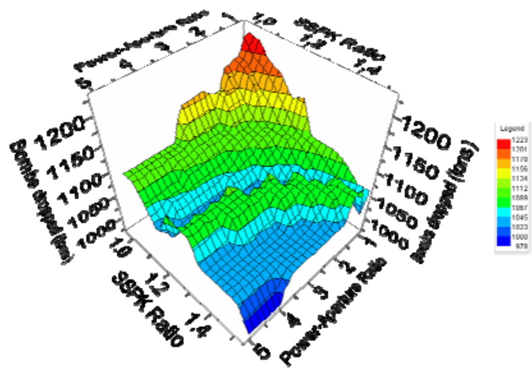
Bombs Leaked (tons)

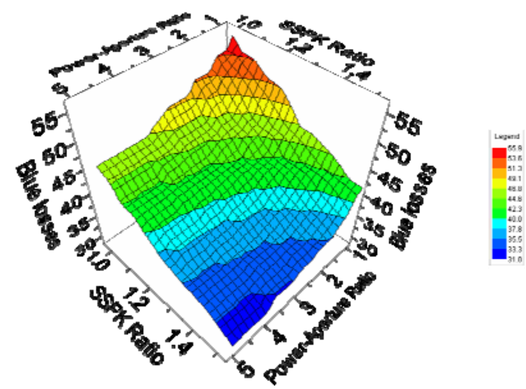


Blue losses





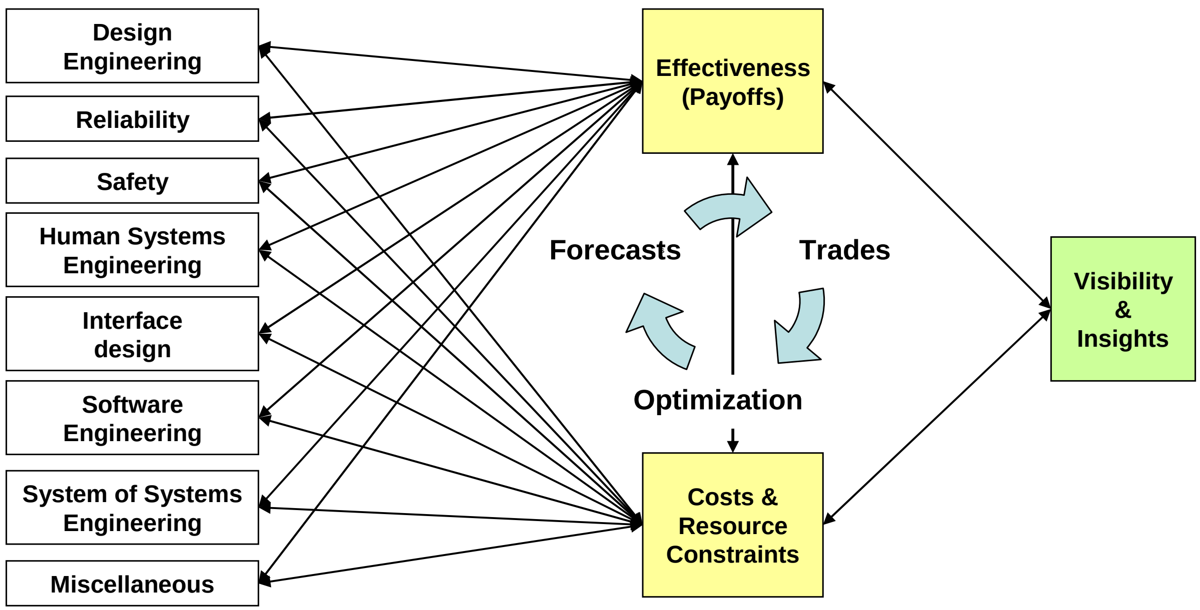




Result: Most cost-effective to improve missile!

What's Next?

- Tailor framework to assess systems engineering disciplines
  - Develop parametric cost and effectiveness relationships for each discipline
  - Use TRACER analysis approach to provide insights into the costs and effectiveness of combinations



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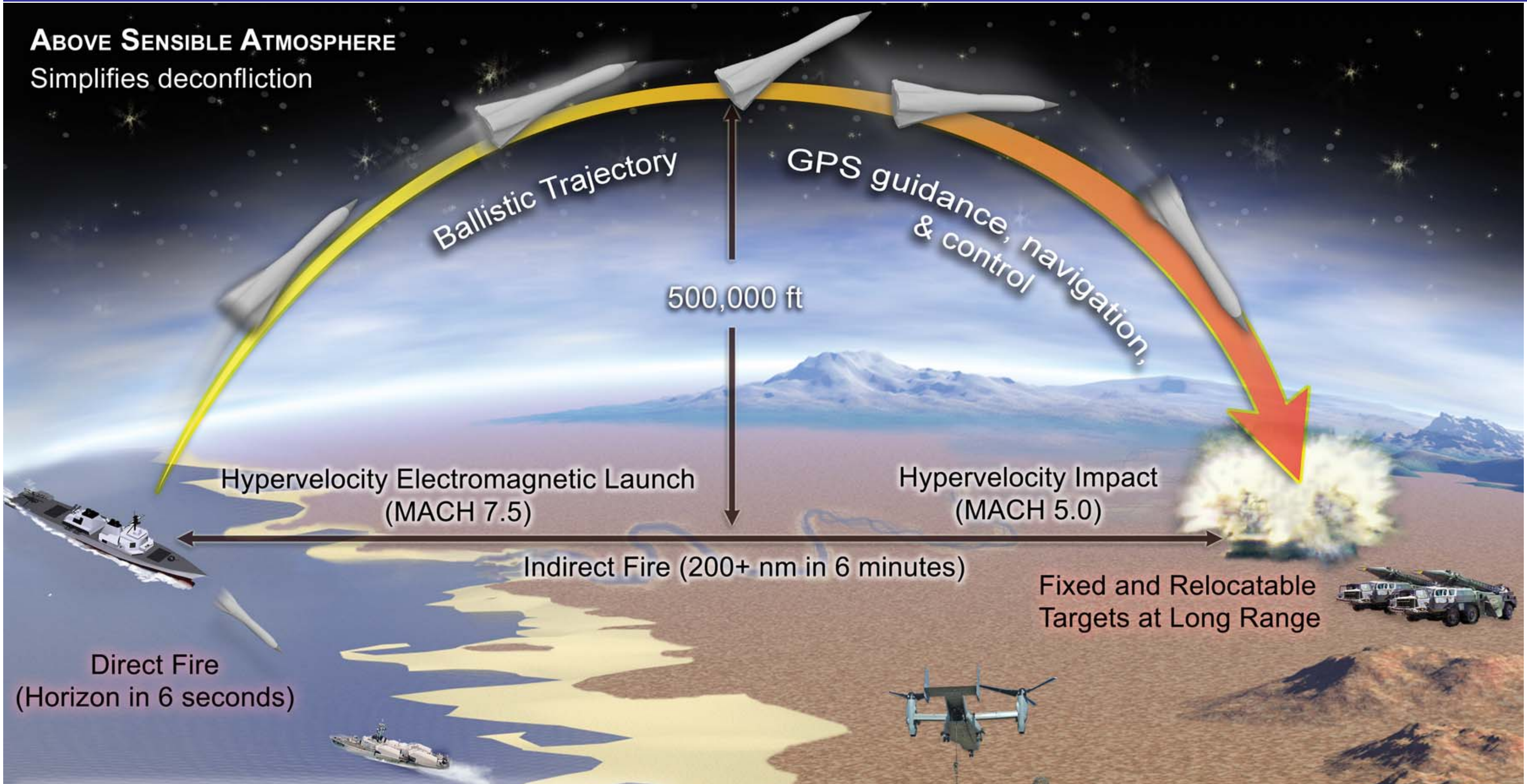
Test and Evaluation of Electromagnetic Railguns

NDIA T&E Conference
March 12-15, 2007

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited

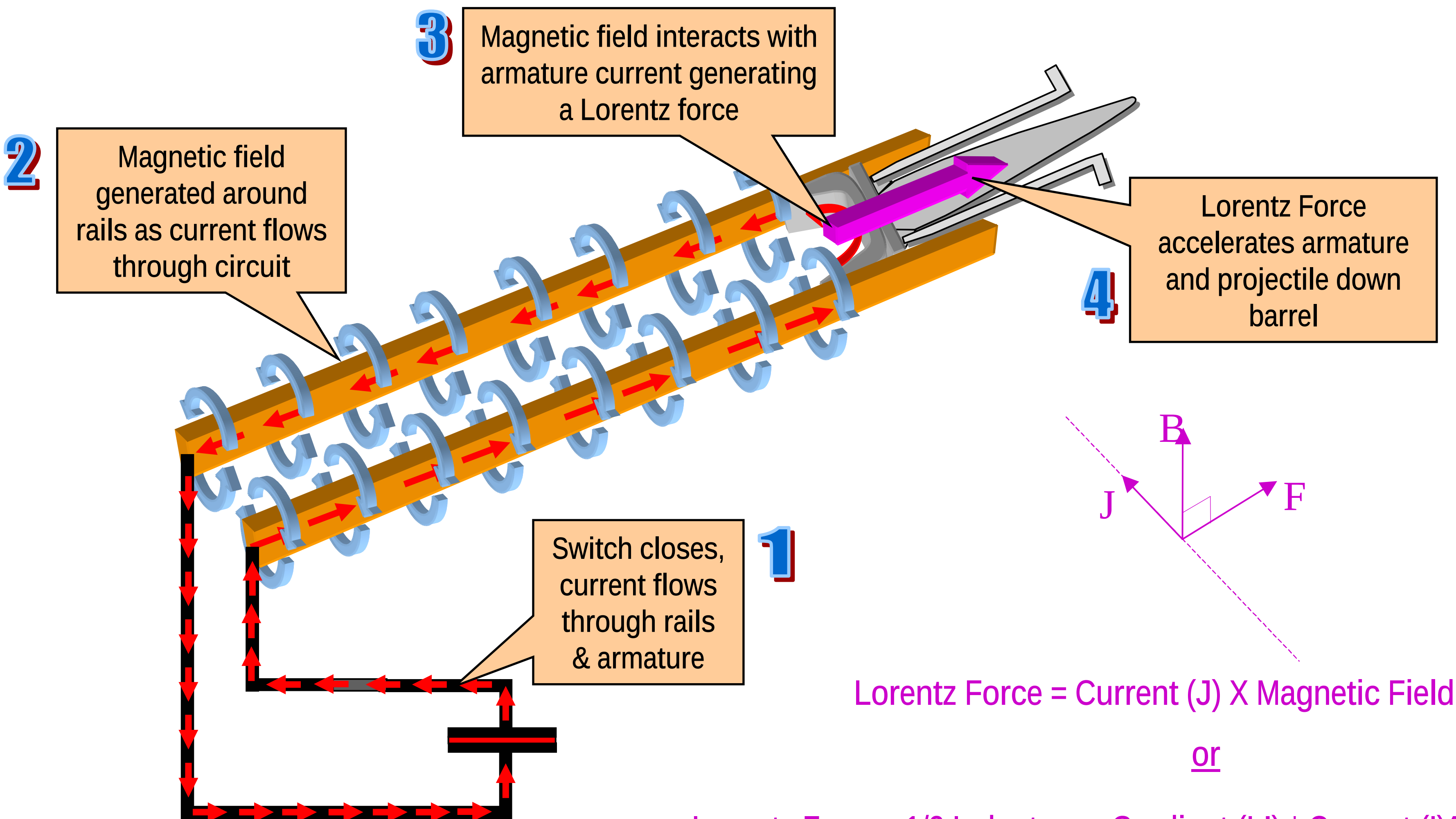
EM Railgun – Game Changing



- Long-Range
- Time-Critical
- Persistent
- All-Weather (24/7)
- No Unexploded Ordnance Issues

- Large Capacity Magazines
- No Propellants
- No Explosive Warheads
- Increased Ship Design Options
- Reduced Ship Vulnerability
- Leverages Navy Investment in Integrated Power System

How it Works

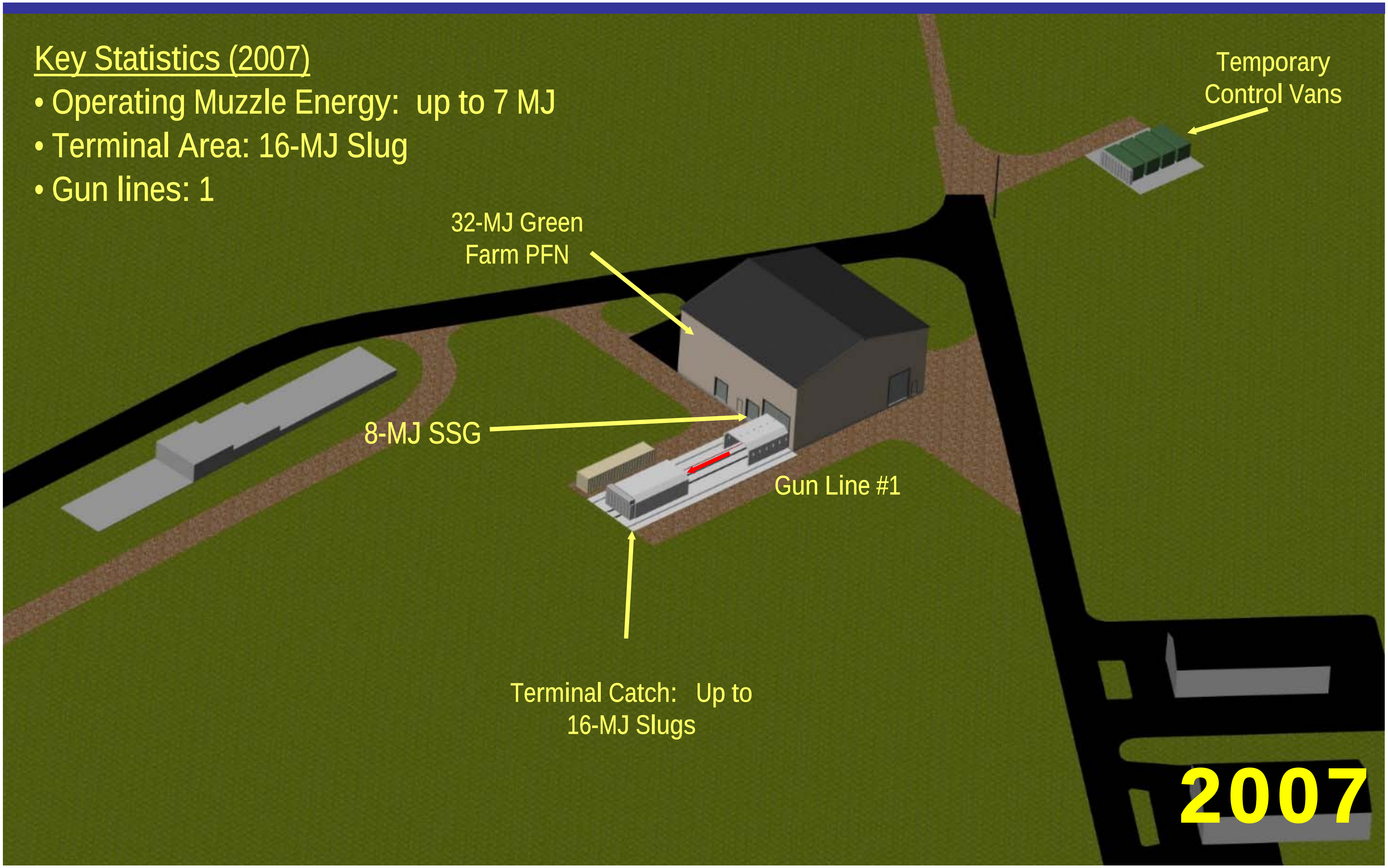


Lorentz Force = Current (J) X Magnetic Field (B)

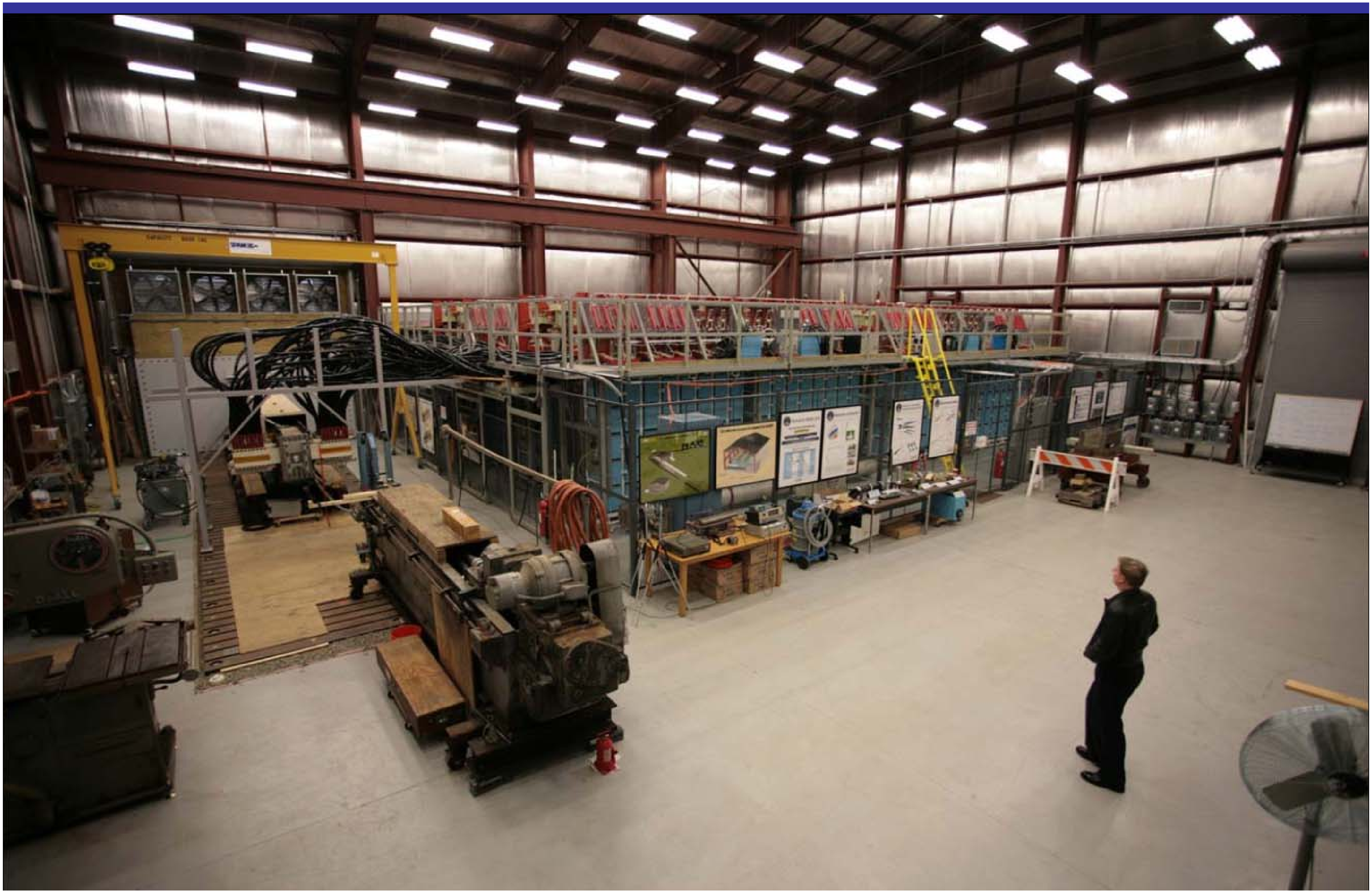
or

Lorentz Force =1/2 Inductance Gradient (L') * Current (I)^2

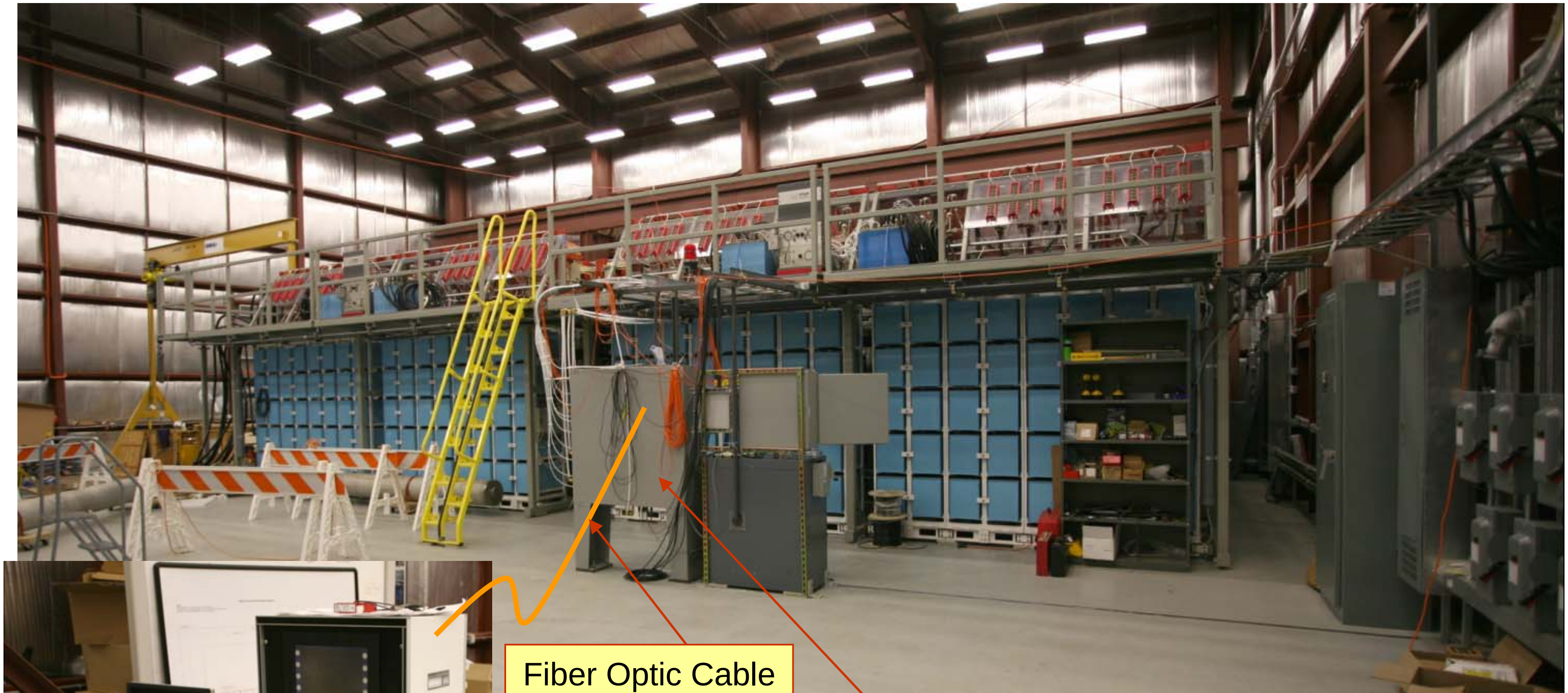
Current Facility



Current Facility



32-MJ PFN



Fiber Optic Cable

Controls Cabinets

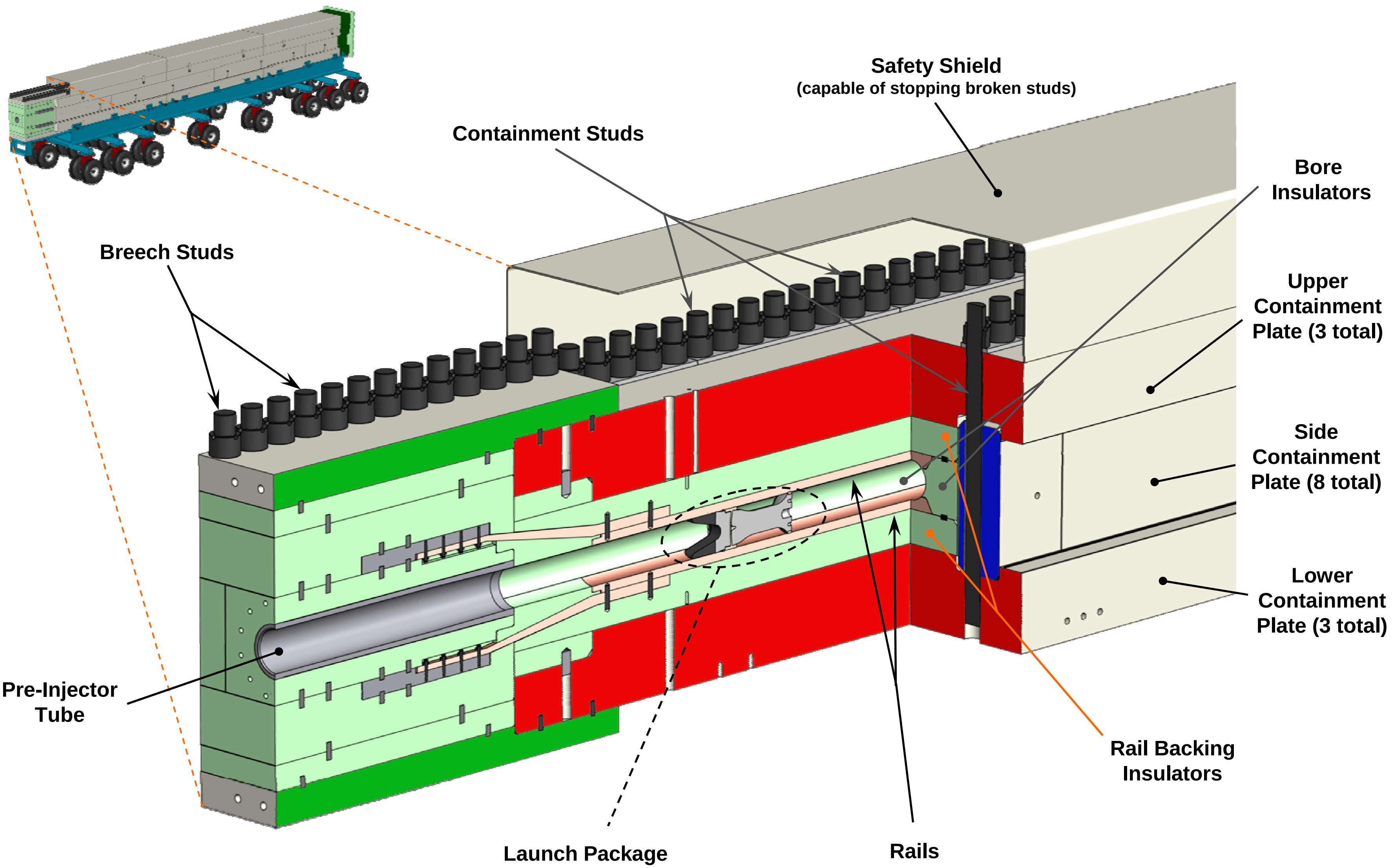
System Controller
(Located in Control Van)

Switching and Output Cables

350-MCM Coaxial Cable

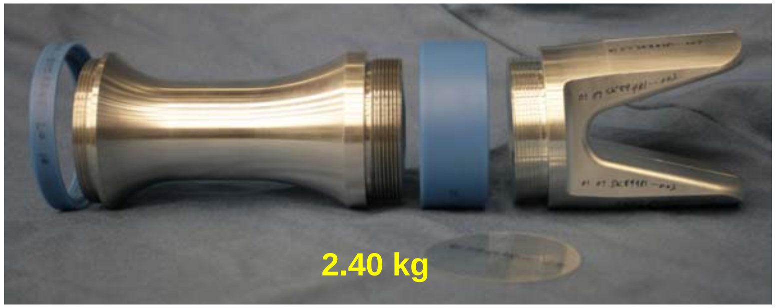
Spark Gap Switch

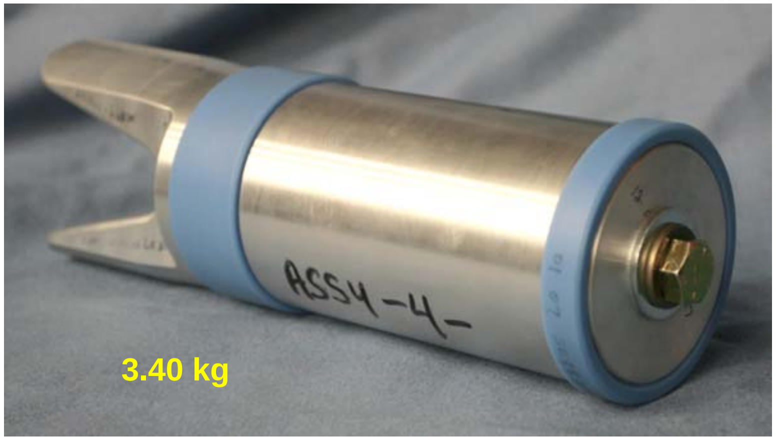
SSG Construction

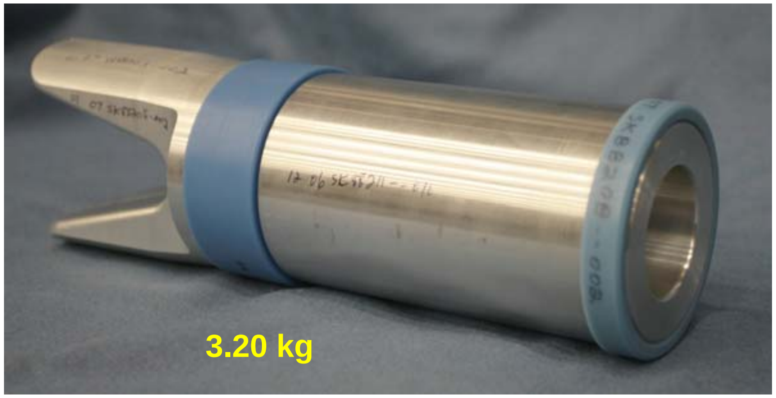


Launch Package

- Total Mass = 2.3-3.4 kg
- Aluminum Slug and Armature
- Nylon Bore Riders
- Design based on earlier work at Kirkcudbright and Greenfarm

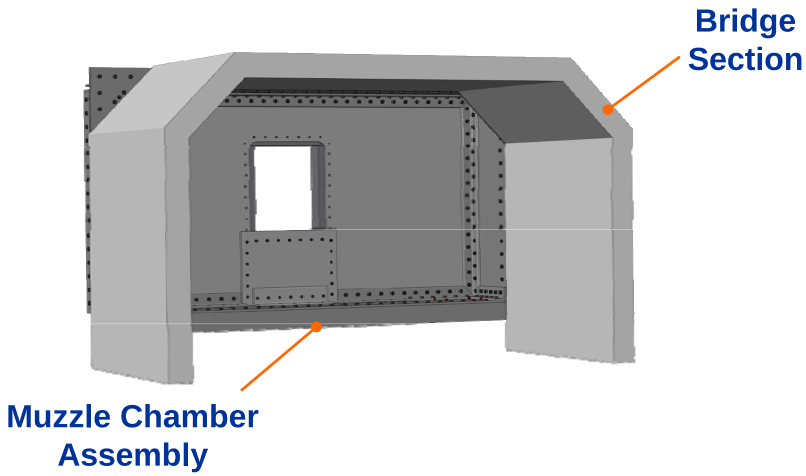


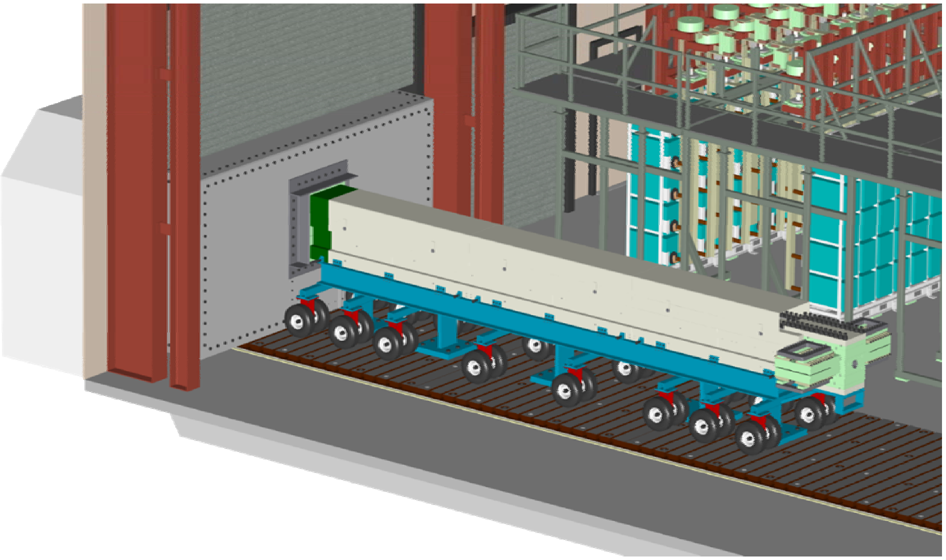




Gun - Facility Interfaces

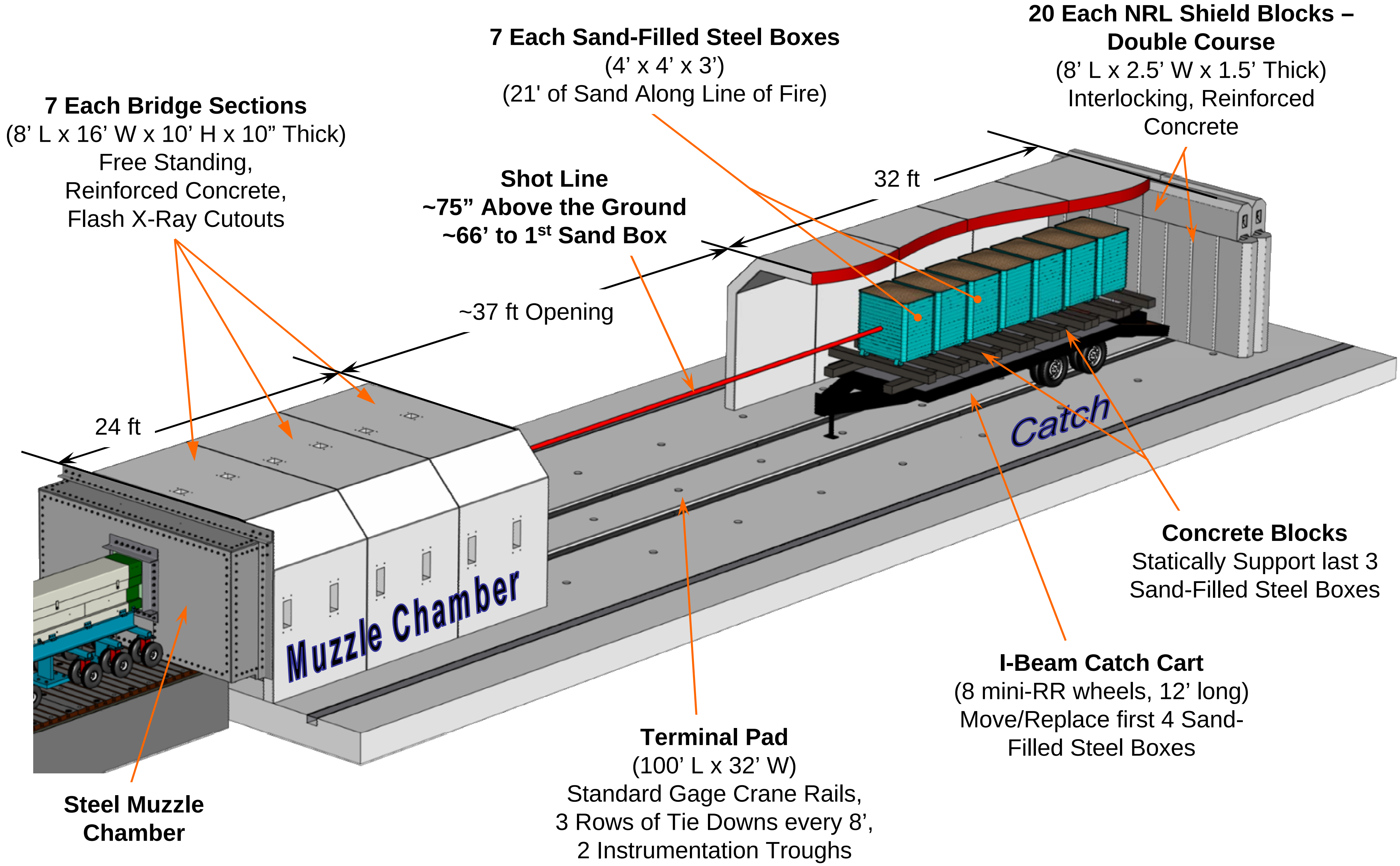
<u>Muzzle Chamber</u>
- **1" Thick A36 Steel Plate**
- **Bolts Directly to Gun Foundation**
- **Bolts Directly to Bridge Section**
- **Adaptable to Variety of Launchers**





<u>Recoil Plates</u>
- **3" Thick A36 Steel Plate**
- **Bolt Directly to the Gun Foundation Plates**
- **Bolt Directly to Underside of SSG**

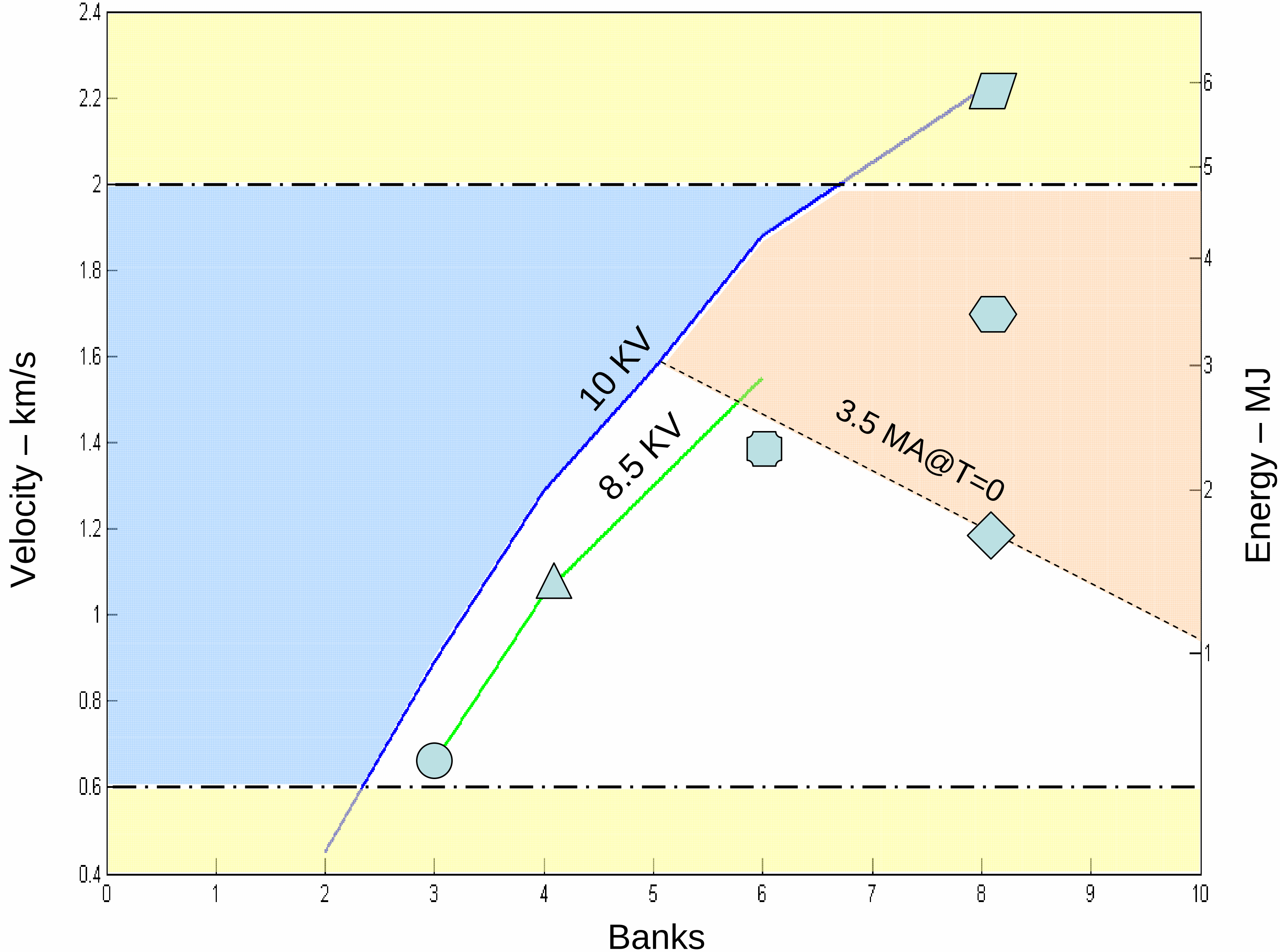
Terminal Area Design



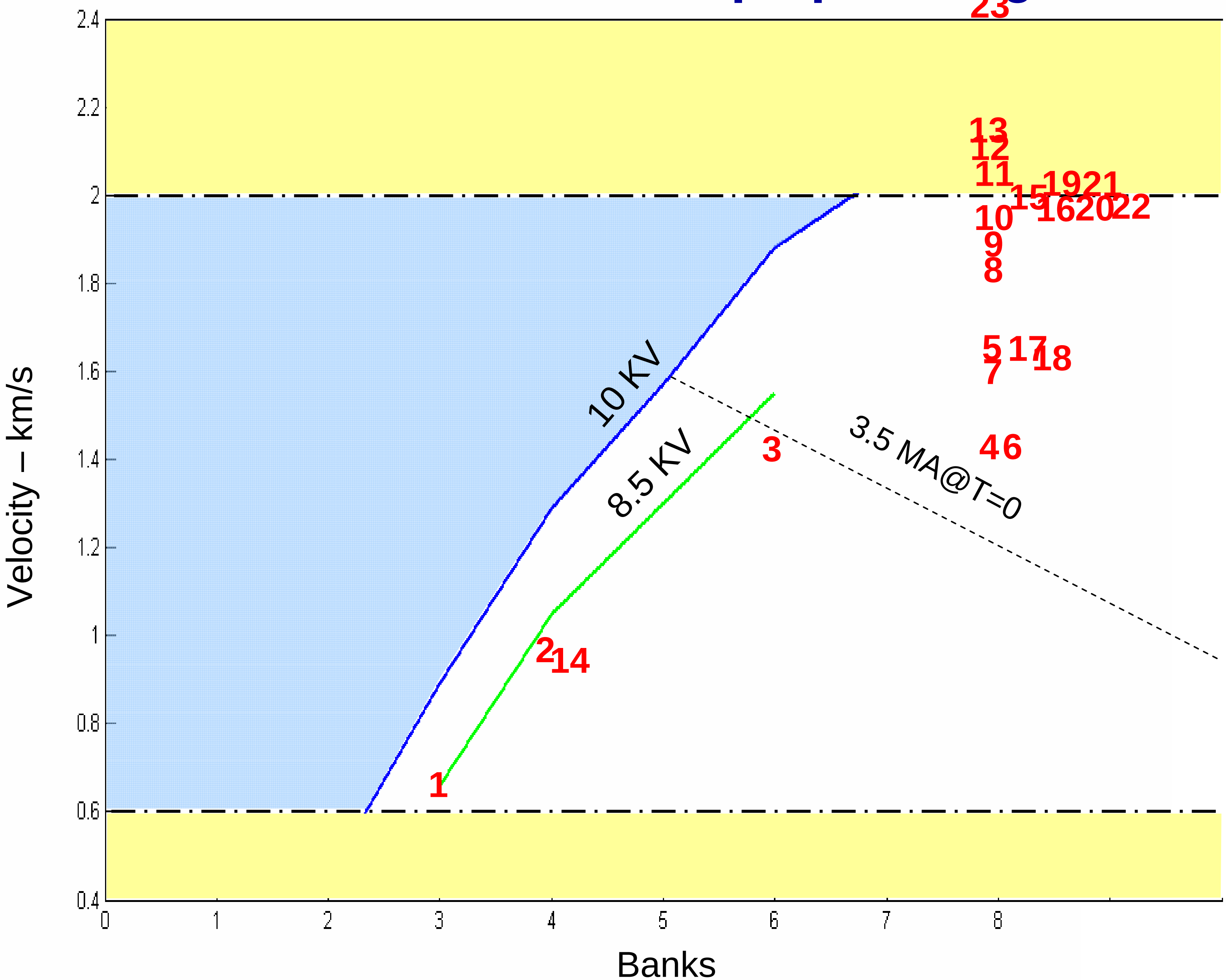
Catch Component

- 7 Each Sand-Filled Steel Boxes, Total of 14 On Hand
  - 4 ft x 4 ft x 3 ft
  - Wt 5740 lbs when Filled
  - 21 ft of Sand along Line of Fire
  - Open Top, Stackable, 4-Way Forklift Entry
- I-Beam Catch Cart
  - Support the First 4 Sand Boxes to Allow Quick Movement & Replacement
  - Runs on Crane Rails Using Mini-Railroad Wheels
- Concrete Blocks
  - Support the Last 3 Sand Boxes

Power Ramp Up Testing Plan (2.4kg)



Actual Power Ramp Up Testing



Test Results

Video of Test Results

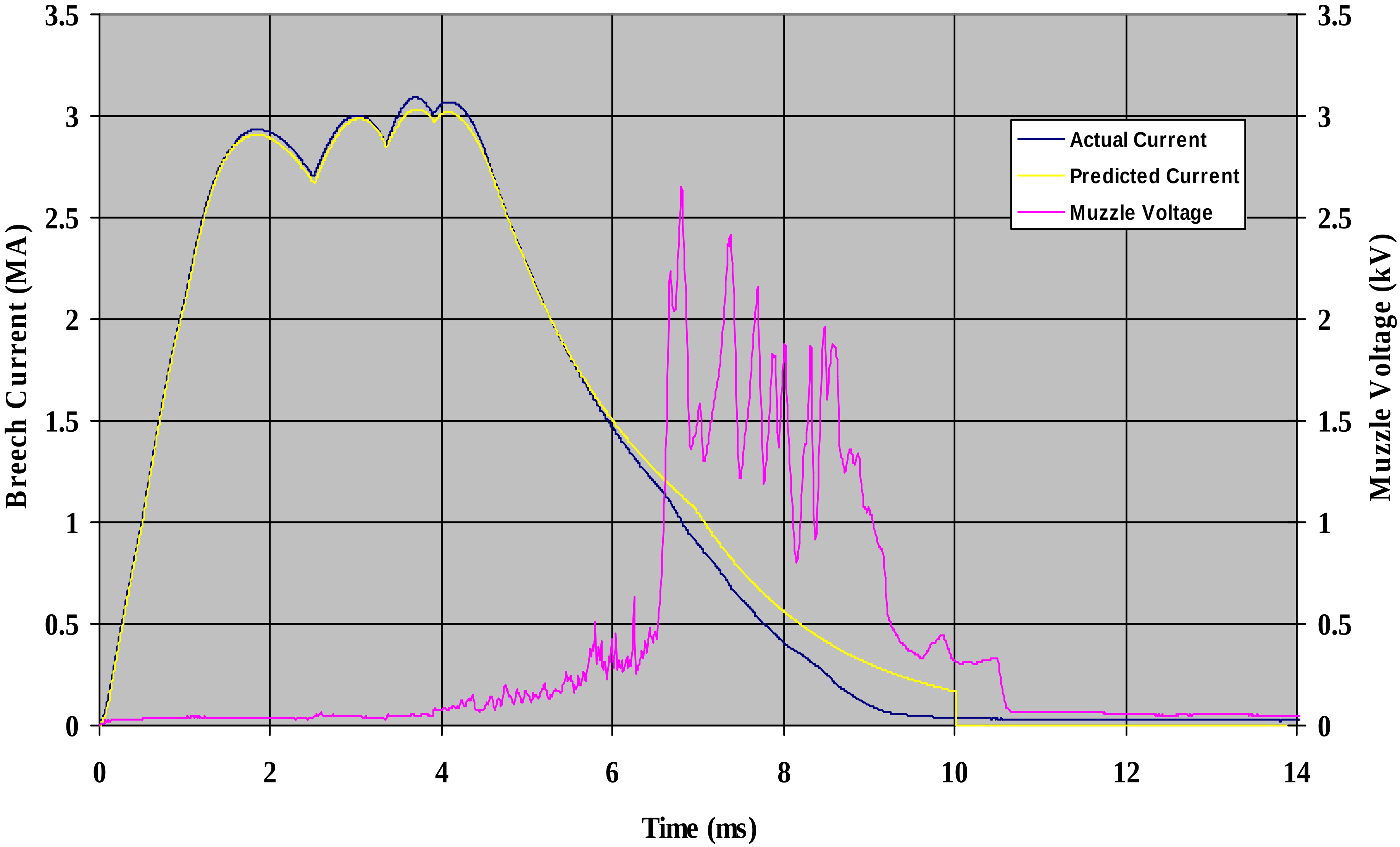
Test Results

Shot	Mass (KG)	Charge Voltage (KV)	Peak Current (MA)	Muzzle Velocity (m/s)	Muzzle Energy (MJ)	Efficiency (%)
1	2.4	8.2	1.7	837	0.841	12.6
2	2.41	8.18	1.8	1117	1.5	16.9
3	2.416	7.85	2.35	1560	2.94	24.5
4	2.456	6.25	2.79	1540	2.91	28.3
5	2.456	6.85	2.83	1760	3.8	30.7
6	3.29	6.9	3	1500	3.7	29.4
7	3.29	7.68	3.13	1680	4.64	29.8
8	3.288	8.3	3.09	1850	5.63	30.9
9	3.29	8.6	3.1	1920	6.06	30.9
10	3.29	8.9	3.09	1990	6.51	31
11	3.288	9.2	3.1	2070	7.04	31.4
12	3.346	9.68	3.13	2117	7.5	30.2
13	3.2	9.65	3.09	2146	7.38	29.8

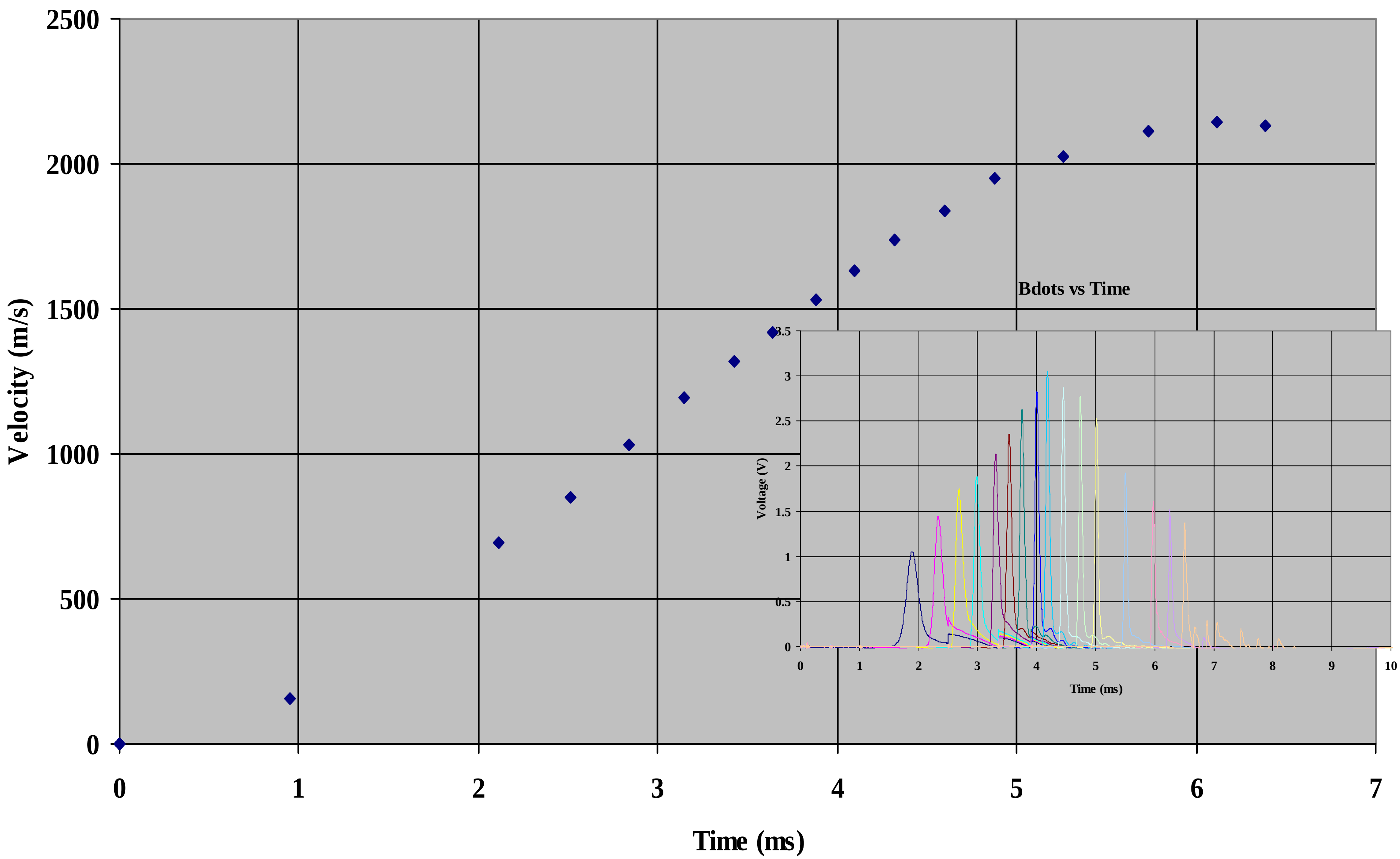
Test Results (continued)

Shot	Mass (KG)	Charge Voltage (KV)	Peak Current (MA)	Muzzle Velocity (m/s)	Muzzle Energy (MJ)	Efficiency (%)
14	2.46	8.2	1.87	1106	1.5	16.9
15	2.31	8.01	2.46	2005	4.65	27.4
16	2.89	8.89	2.75	2059	6.13	29.3
17	3.29	7.8	3.18	1722	4.87	30.3
18	3.29	7.8	3.18	1717	4.85	30.1
19	3.402	9.69	2.99	2053	7.17	28.9
20	2.892	8.9	2.75	2025	5.93	28.3
21	2.888	8.9	2.75	2019	5.88	28.1
22	2.89	8.9	2.73	2012	5.85	27.9
23	2.454	9.49	3.08	2519	7.79	32.7

Shot 13 Breech Current and Muzzle Voltage



Shot 13 Velocity

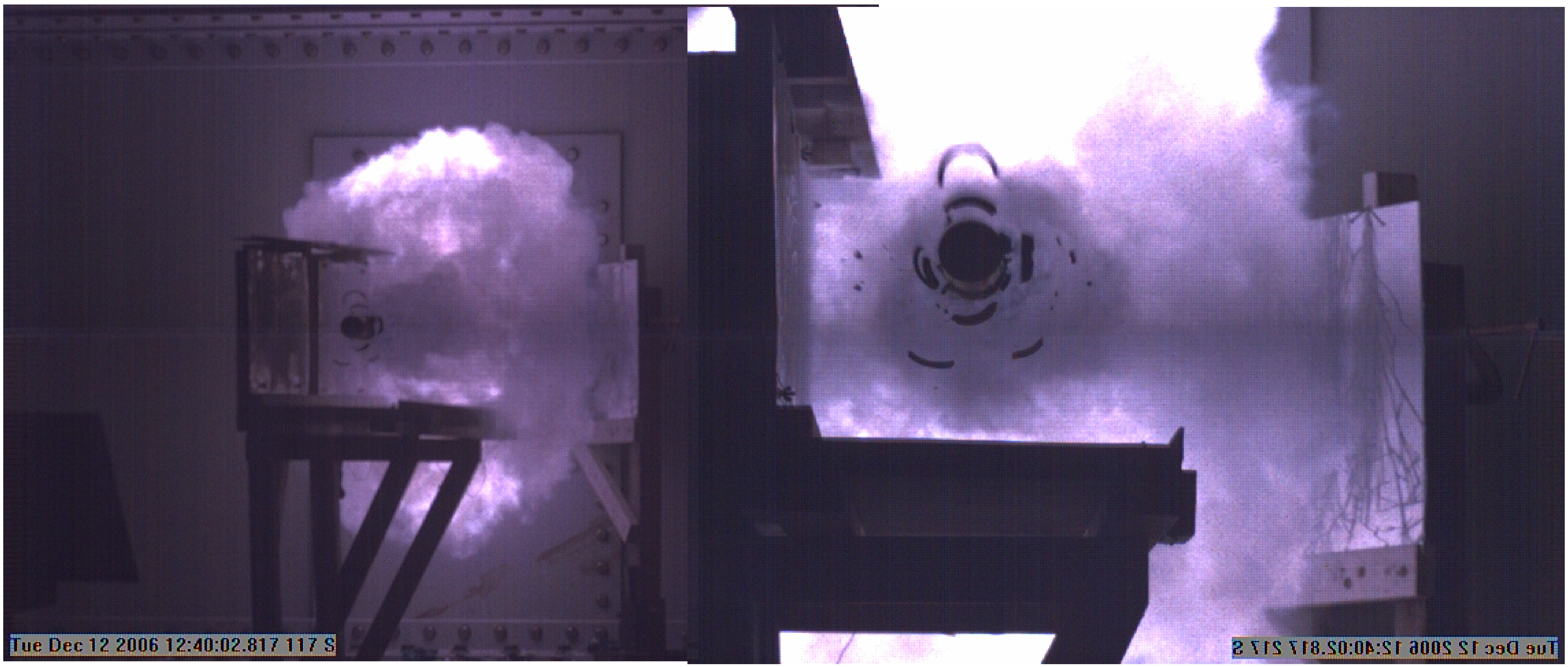


Revolutionary Research . . . Relevant Results

Muzzle Launch View

NAVSEA WARFARE CENTERS DAHLGREN

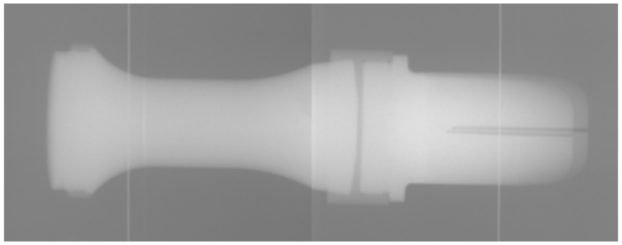
- Shot 7
- Muzzle Arc is 500K Amps at 2.3 KV
- 9 PSI Overpressure at 99” from muzzle

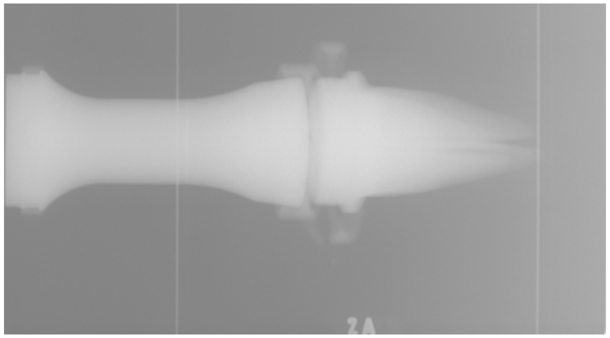


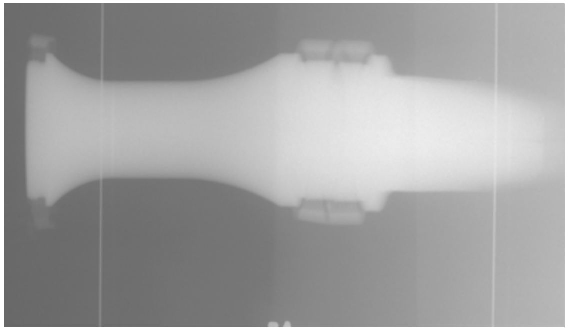
Flash X-ray Images

Static Xray Image | Shot 2 Xray Image | Shot 4 Xray Image

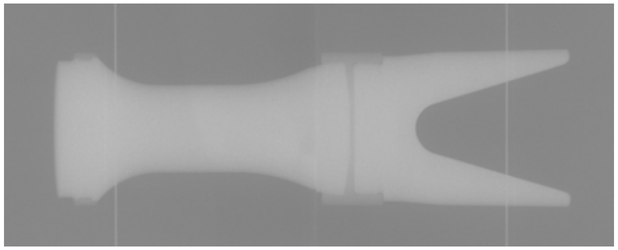
Top View

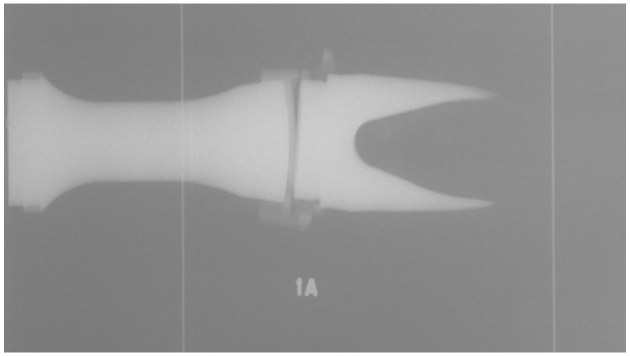


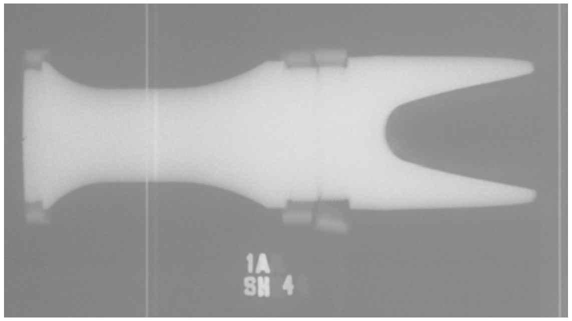




Side View



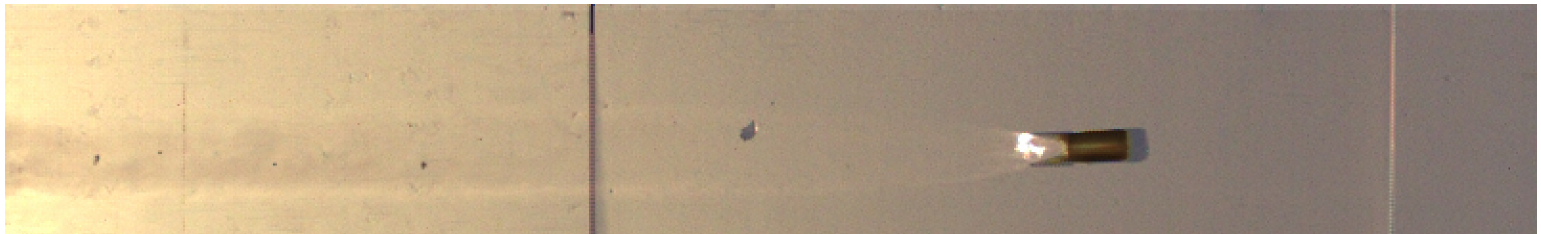




All images are 3 feet from muzzle

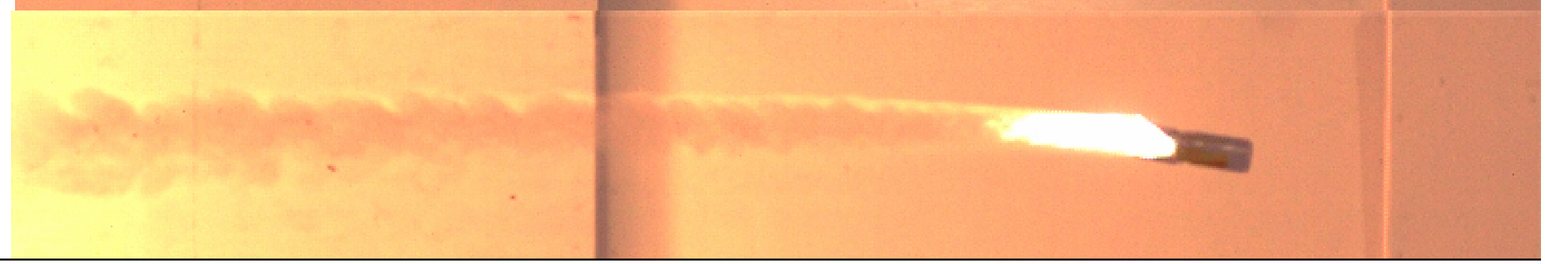
In-Flight Images

Shot 8:

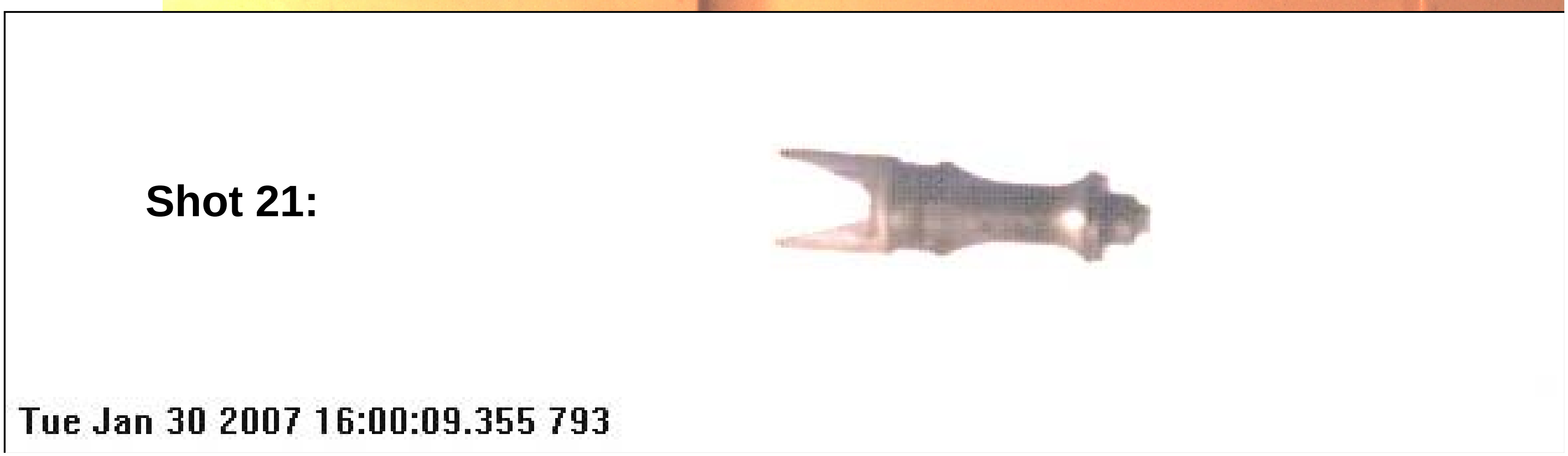


Shot 9:

Shot 10:



Shot 21:



Revolutionary Research . . . Relevant Results

Target Impact

NAVSEA WARFARE CENTERS DAHLGREN

Launch Package Results

Original Launch Package

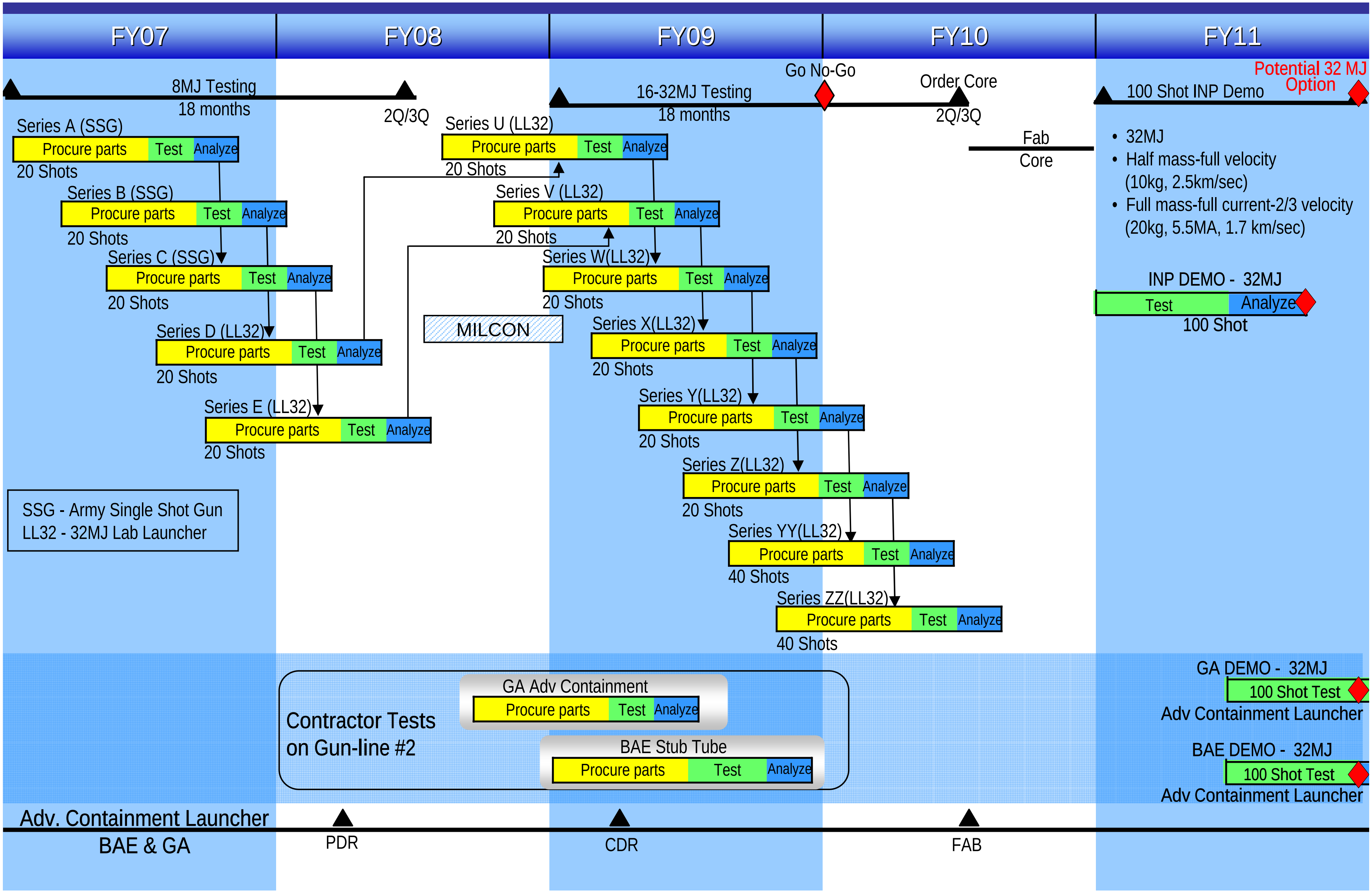
Recovered from Shot 1

Recovered from Shot 2

Bore Life
EMLF Testing Concept

Revolutionary Research . . . Relevant Results

NAVSEA WARFARE CENTERS DAHLGREN

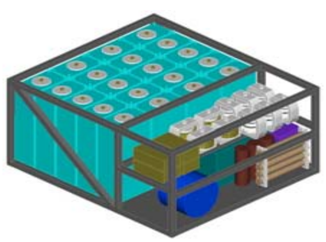


S&T Technology Challenges

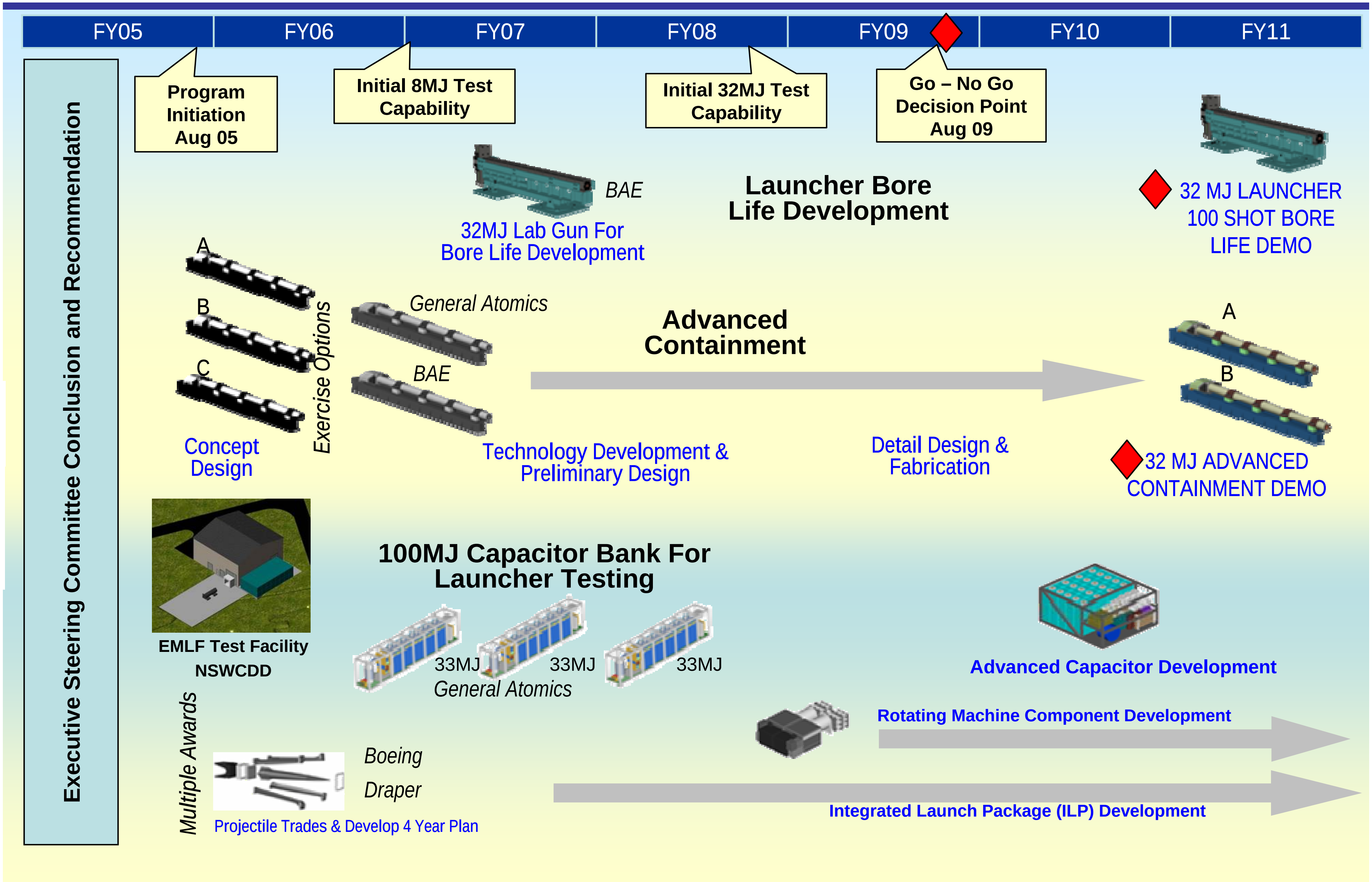
- Launcher
  - Multi-shot barrel life
  - Barrel construction to contain rail repulsive forces
  - Scaling from 8MJ (state of the art) to 32MJ → 64MJ Muzzle Energy
  - Thermal management techniques

- Projectile
  - Gun launch survivability (45 kGee acceleration, Electromagnetic Interference Potential)
  - Hypersonic guided flight for accuracy
  - Lethality mechanics

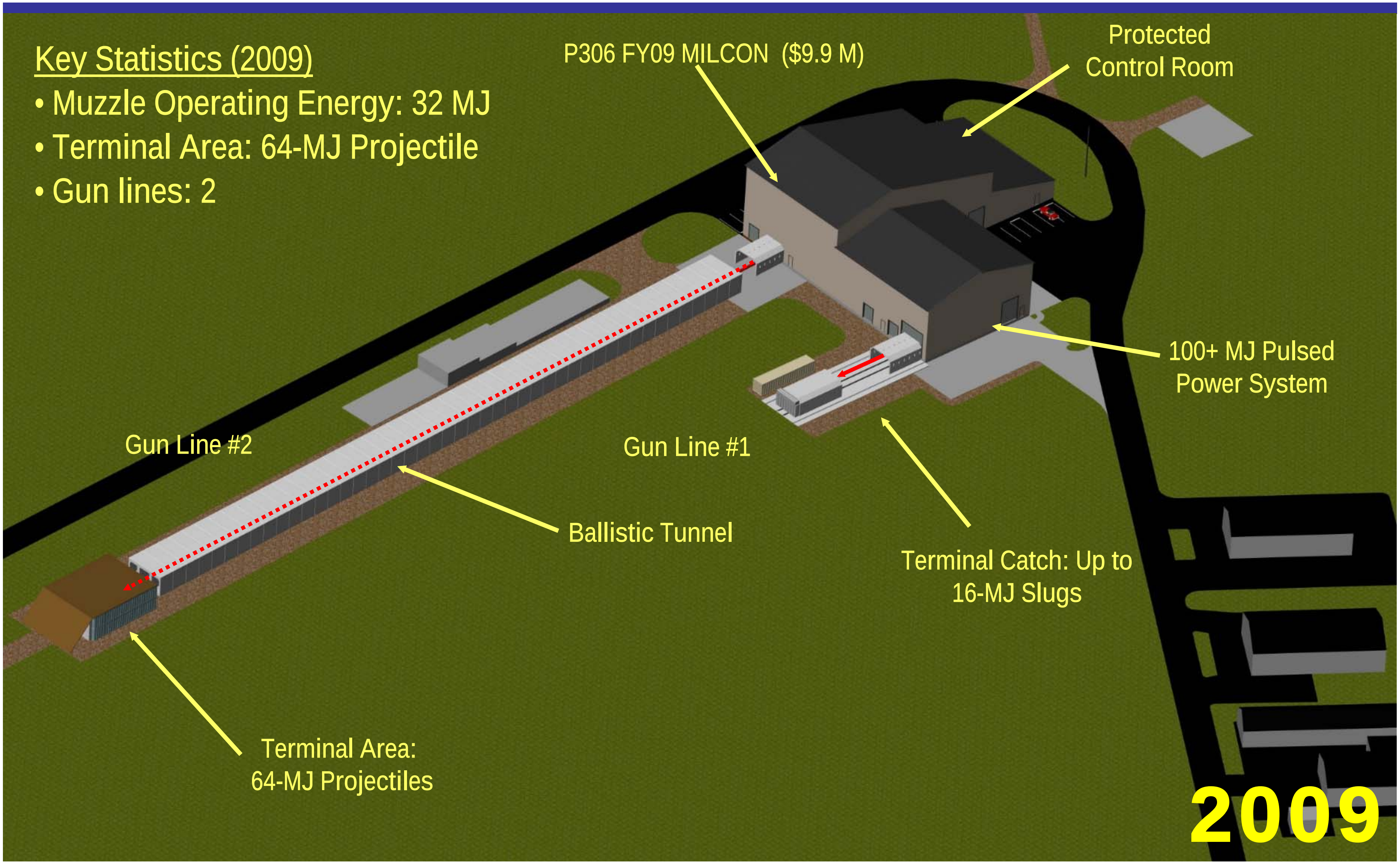
- Pulsed Power System
  - Energy Density
  - Rep rate operation & thermal management
  - Switching
  - Torque management and multi-machine synchronization (rotating machine)



ONR INP Phase I Program



Milcon Addition



Revolutionary Research . . . Relevant Results

Railgun Contact Information

WARFARE CENTERS
DAHLGREN

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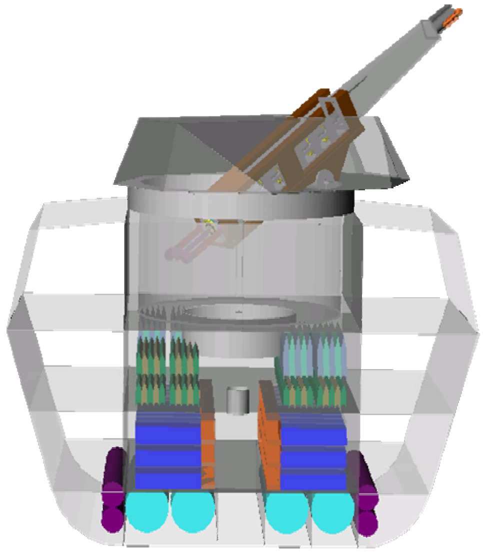
Dahlgren VA 22448-5156
540.653.3186

Mr. Tom Boucher, P.E. (EMLF Test Director)
Naval Surface Warfare Center, Dahlgren (Code 606)
18236 Thompson Road
Dahlgren VA 22448-5116
540.653.6273

Back-up

Navy Electromagnetic Railgun



Why is it important?

- Volume & Precision Fires
- Time Critical Strike
- All weather availability
- Variety of payload packages
- Scalable effects
- Deep Magazines
- Non explosive round/No gun propellant
  - Greatly simplified logistics
  - No IM (Insensitive Munitions) Issues
- Missile ranges at bullet prices

What is it?

- Gun fired with electricity rather than gunpowder
- Revolutionary *250 mile range in 6 minutes*
- Mach 7 launch / Mach 5 hit
- Highly accurate, lethal GPS guided projectile
- Minimum collateral damage

Who needs it?

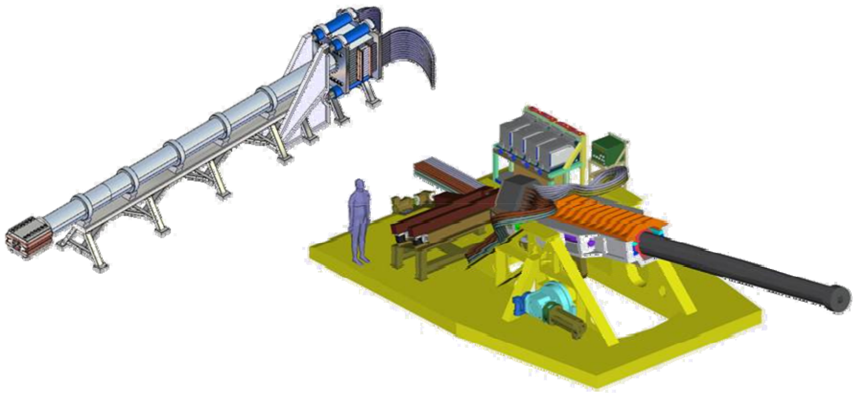
- Marines and Army troops on ground
- Special forces clandestine ops
- GWOT
- Suppress air defenses

When?

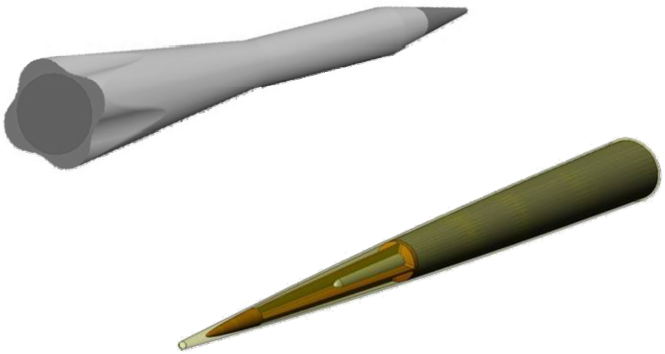
- Feasibility Demo 2011
- System Demo 2015
- IOC 2020-2025

Naval Railgun – Key Elements

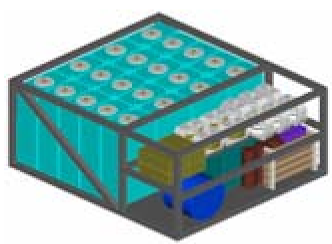
Launcher

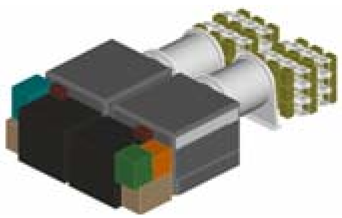


Projectile



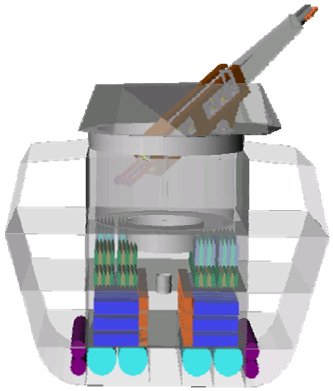
Pulse Forming Network (PFN)





Capacitors or Rotating Machines

Ship Integration

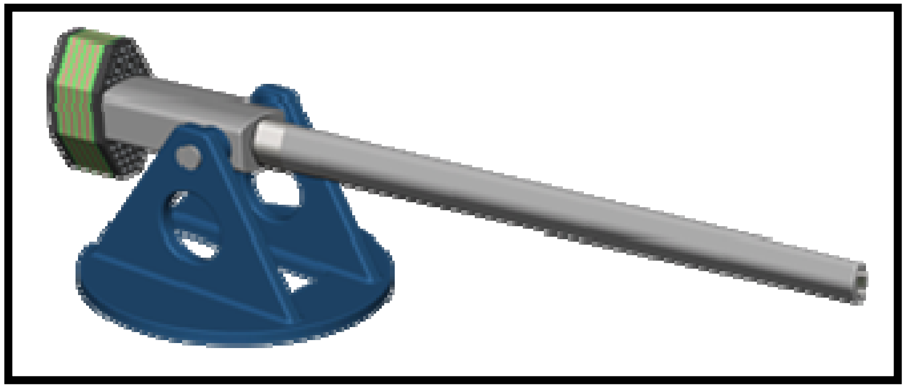


Key Parameters for Sizing a Naval EM Launcher

Pulse Forming Network Size

½ * Launch Mass * Muzzle Velocity^2

Desired Muzzle Energy



Current Profile

- Rail Separation Forces
- Transient Localized Heating

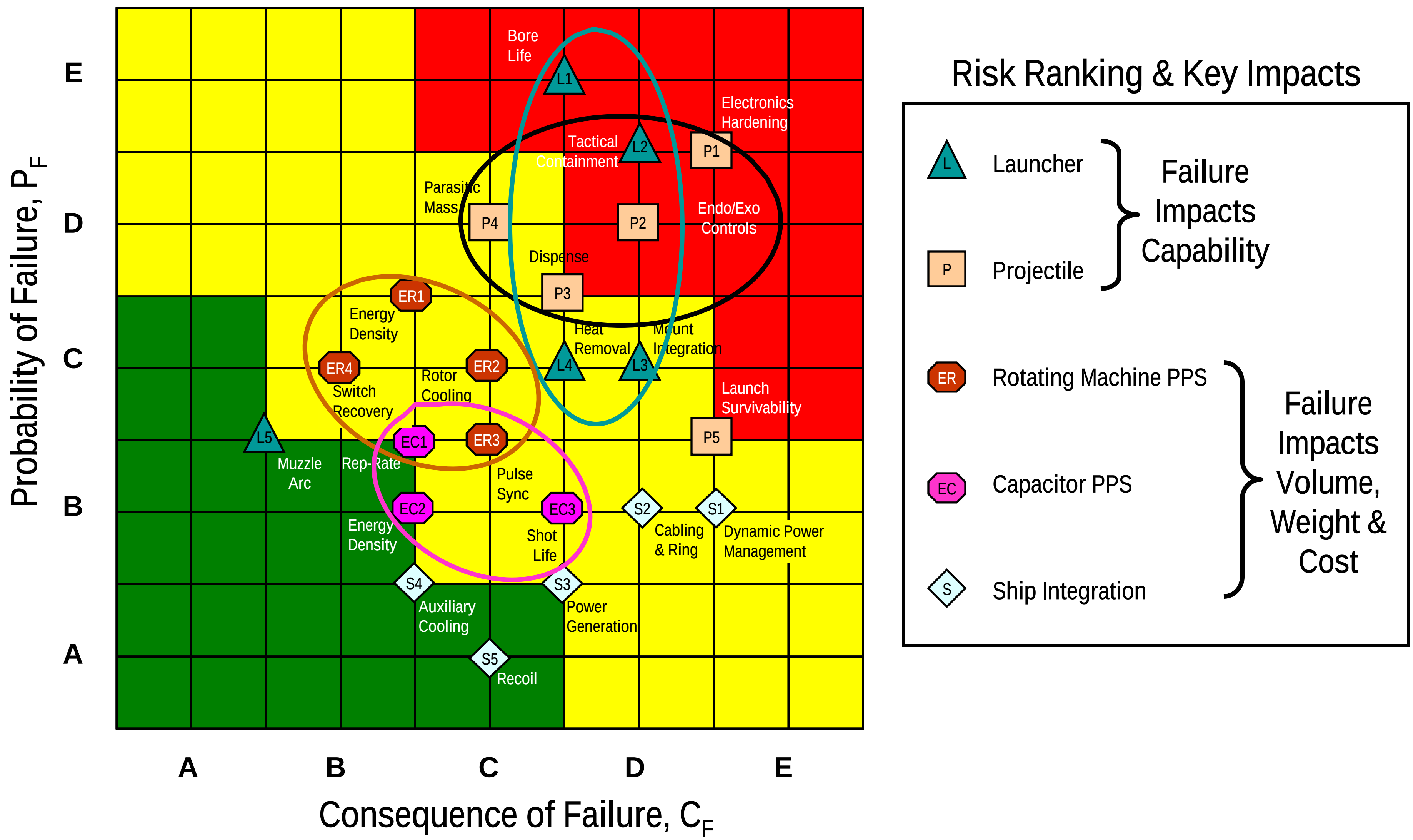
Bore Size & Shape

Launcher Efficiency

Barrel Length

- Max Projectile Acceleration
- Bulk Rail Heating

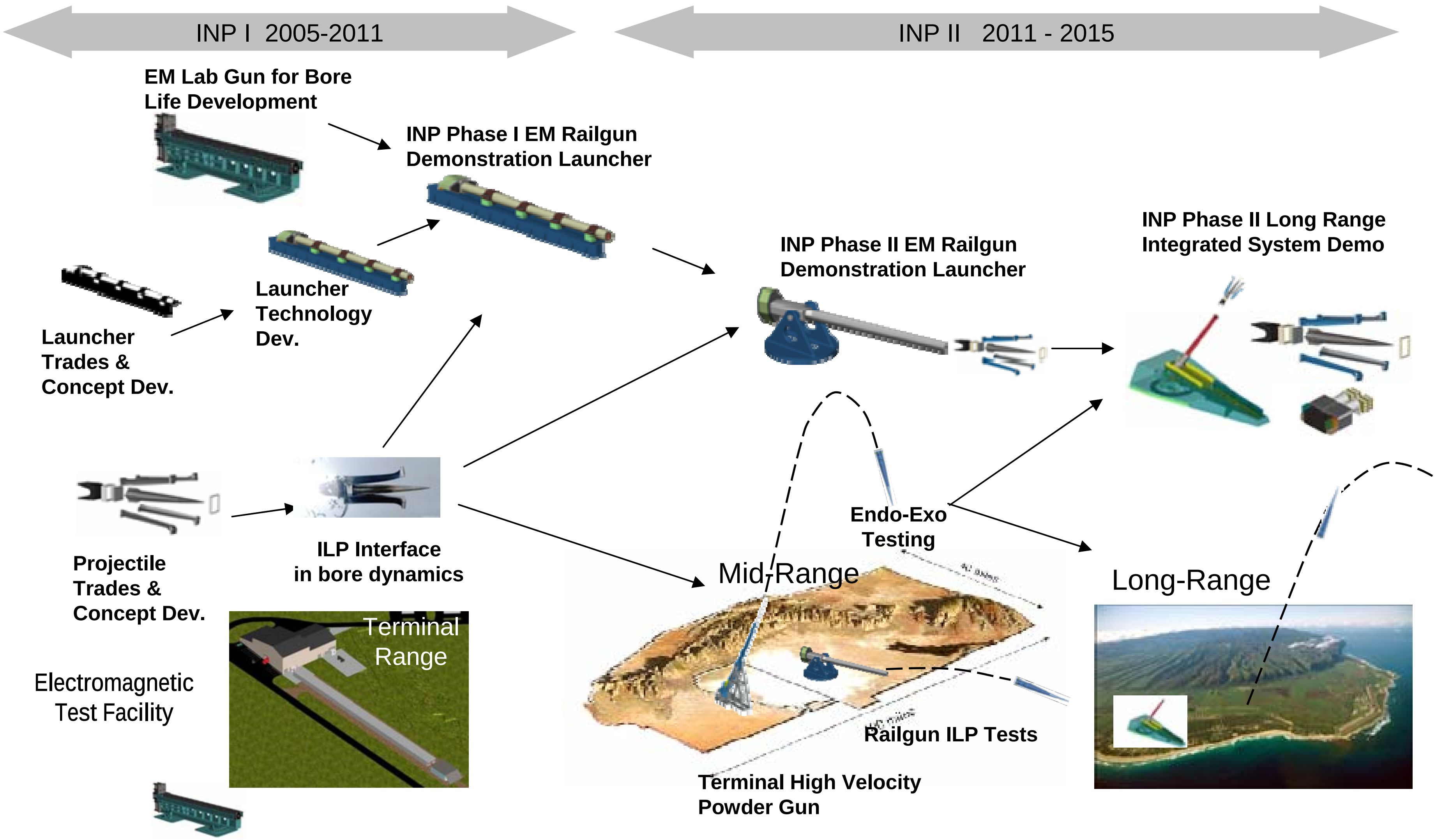
Risk Matrix Summary



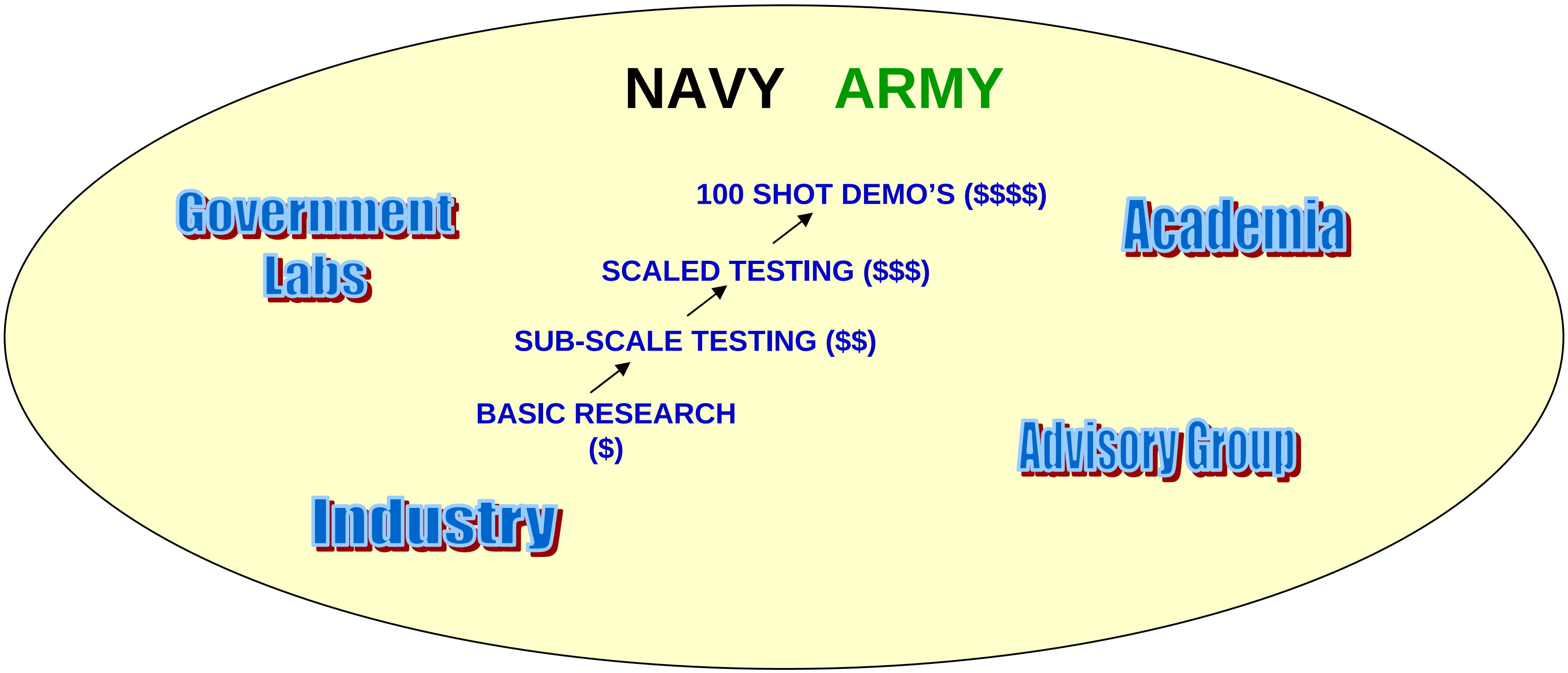
ONR INP Phase 1 Objectives

- Traceability to 64MJ, 6-10 round / min indirect fire weapon system
- Bore Life
  - 32 Mega-Joule (Muzzle Energy) EM Lab Launcher
  - 10kg launch package; full muzzle velocity of 2.5km/sec
  - 20kg launch package with full current of ~5.5MA
  - Demonstrate more than 100 shot bore life
- Containment
  - 32 Mega-Joule Advanced Containment Launcher
  - 10kg launch package; full muzzle velocity of 2.5km/sec
  - 20kg launch package with full current of ~5.5MA
  - 1000+ round predicted containment structural barrel life
  - Design for thermal management at a rate of 6 round / min
  - Design launcher for minimal round dispersion
  - Transportable on pallets and/or in sea containers,
  - Consider marine environment

Integrated System Demo Strategy



Bore Life Consortium



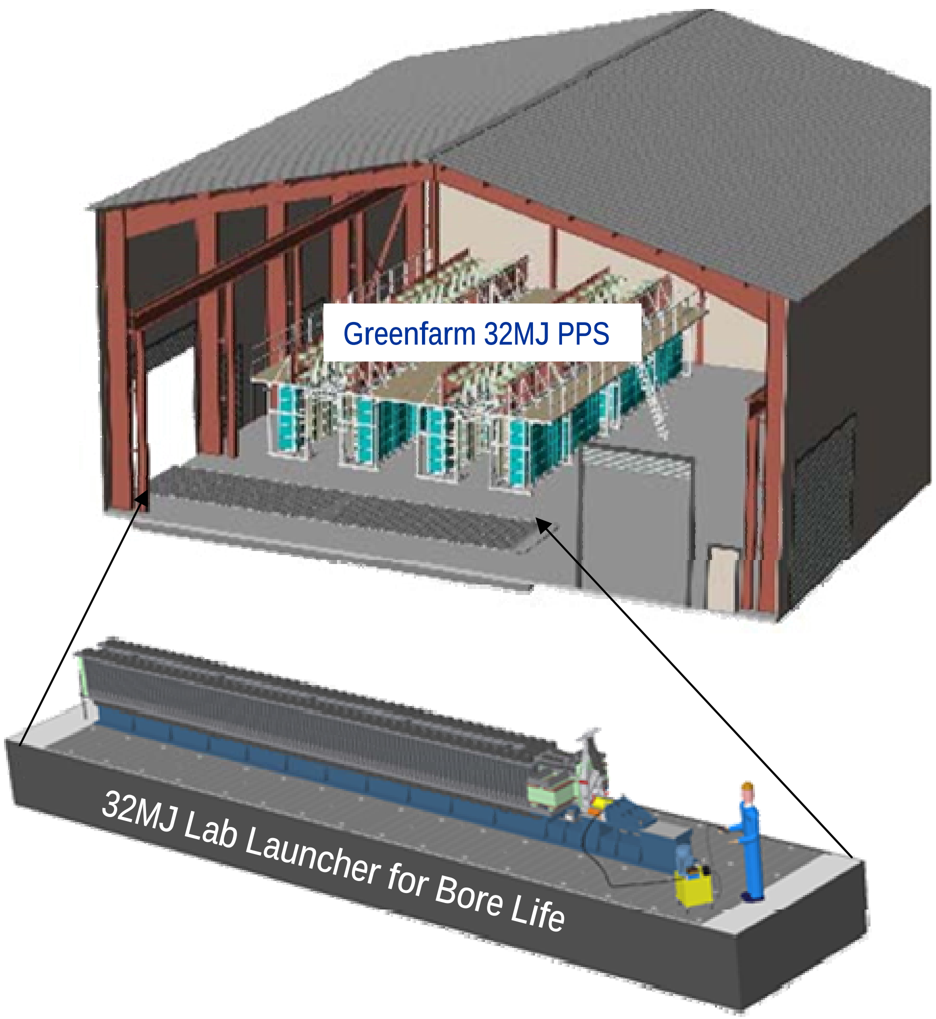
- Spans Basic Research to Full-Scale Demo's
- Parallel development paths via multiple research sites
- Avoids Duplication
- Efficient use of test resources

- Supports both Navy and Army EM Efforts
- Government purpose data rights to permit competition during the acquisition phase.

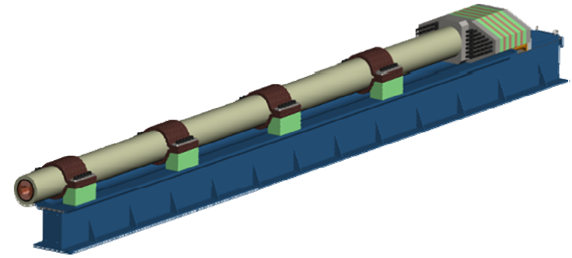
Coordinated Development!

Bore Life and Containment

Lab Launcher - EMTF



Advanced Containment Launcher



Phase	Phase of Project	Period
Basic	Conceptual Design Trade Studies	7 mos.
Army Add	Trade Studies for Army Application	3 mos.
Option I	Technology Development and Preliminary Design	30 mos.
Option II	Detailed Design, Fabrication and Demonstration	29 mos.

Advanced Containment Launcher

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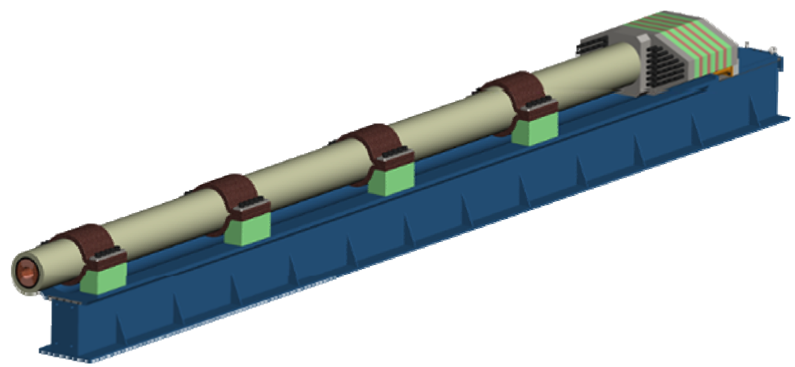
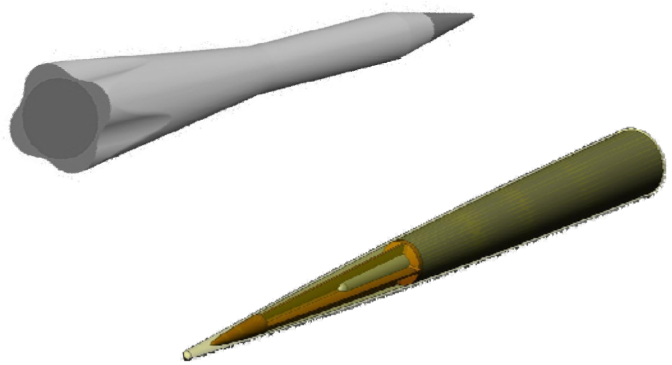


General Atomics Team

Northrop Grumman Team

BAE Team

Projectile Concept Trades



Description of Effort

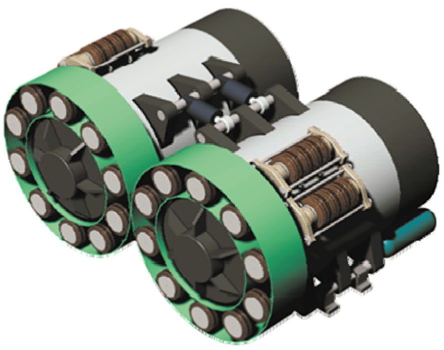
- Develop long range projectile concept
  - Lethal
  - Consistent with Navy CONOPS
  - Compatible with any EML gun development
- Identify critical development
  - GN&C
  - Aerobody (drag and thermal protection)
  - launched survivability
- Produce a development plan

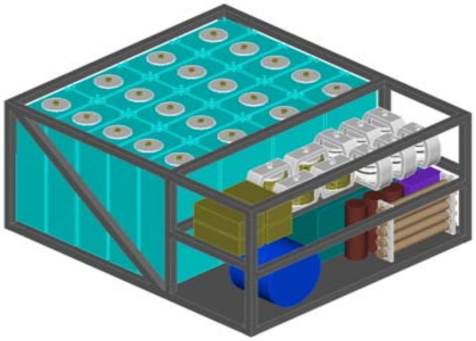
The Boeing AASP Team

Draper Team

Advanced Pulsed Power

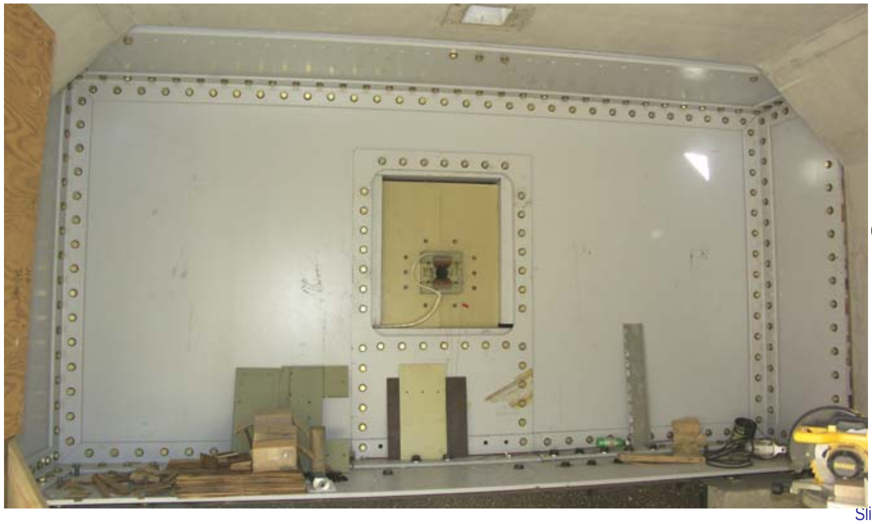
- Rotating Machine
  - Watch Army Effort (Demo in FY08)
  - Navy Specific Critical Component Development
- Advanced Capacitor
  - Increased Energy Density
  - Thermal Management for Multi Shot Operation

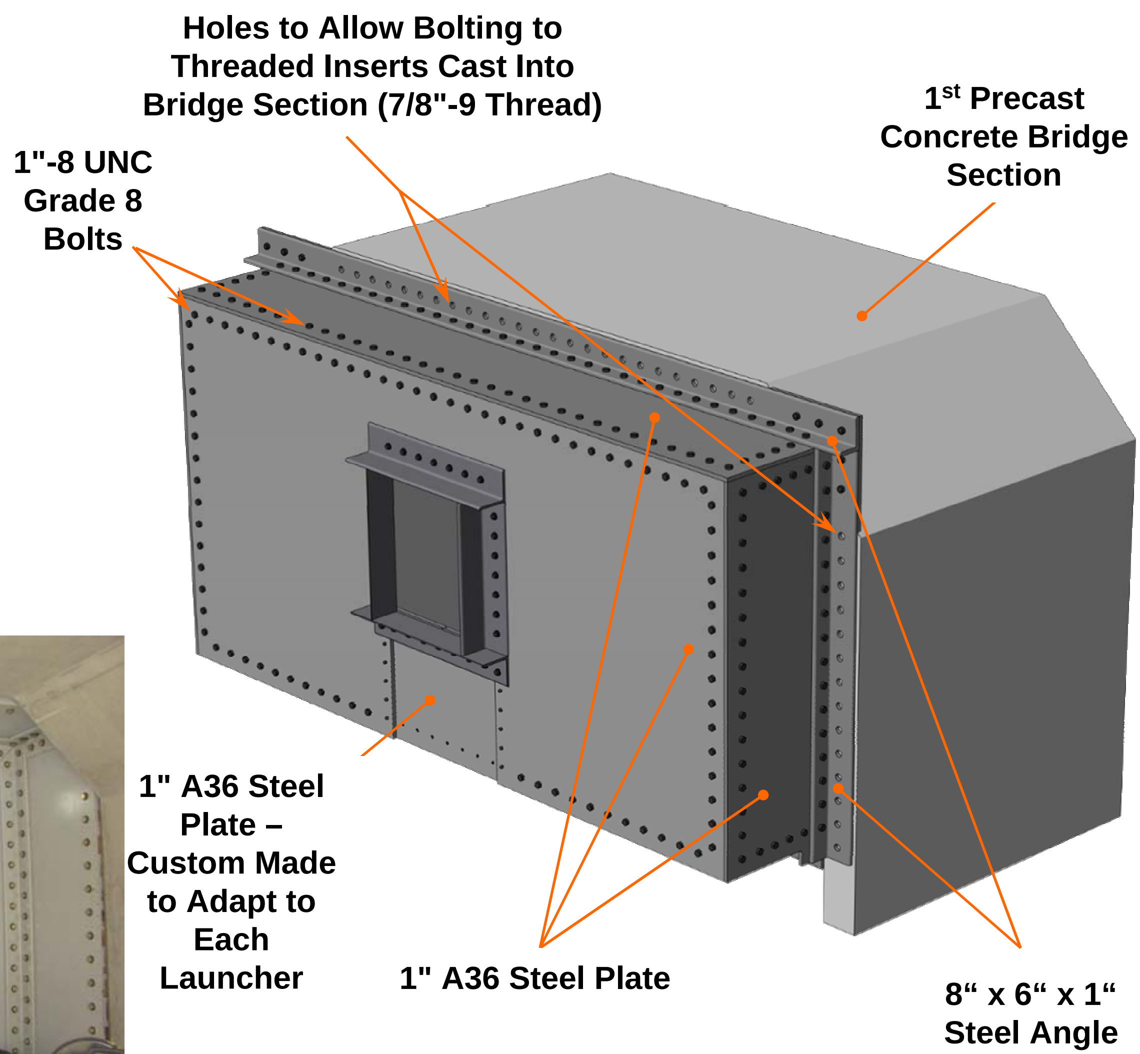




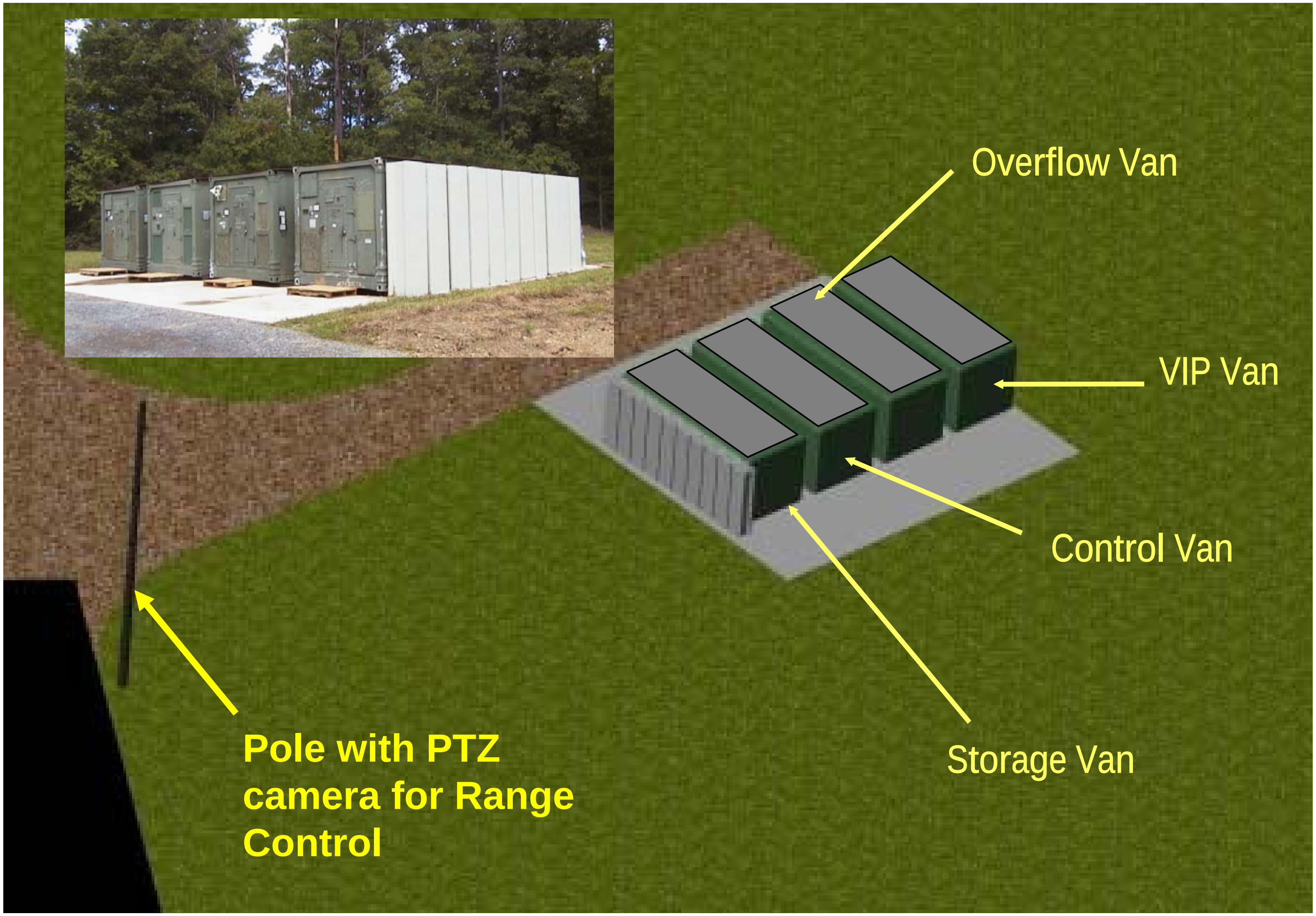
Steel Muzzle Chamber Component

- Steel Muzzle Chamber
  - Mates to both SSG & Lab Launcher
  - Bolts to 1st Concrete Bridge Section
- Collar Plates Seal Gaps between Launcher & Chamber

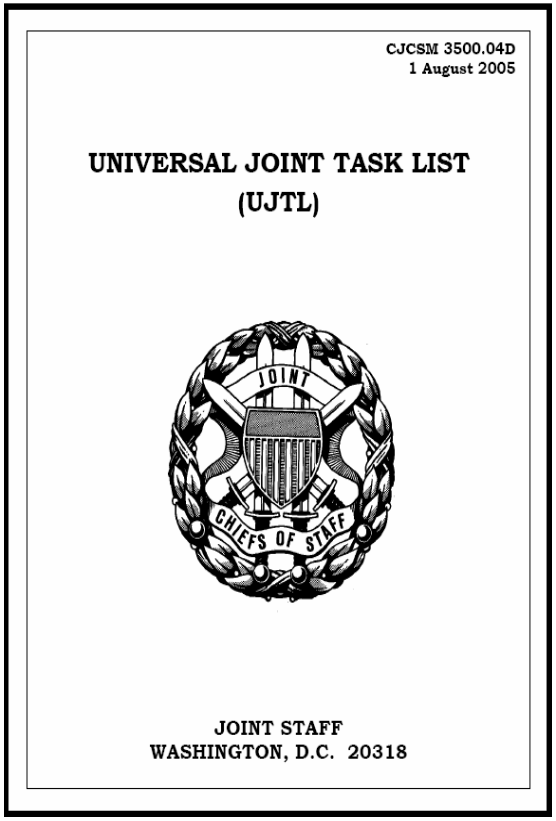


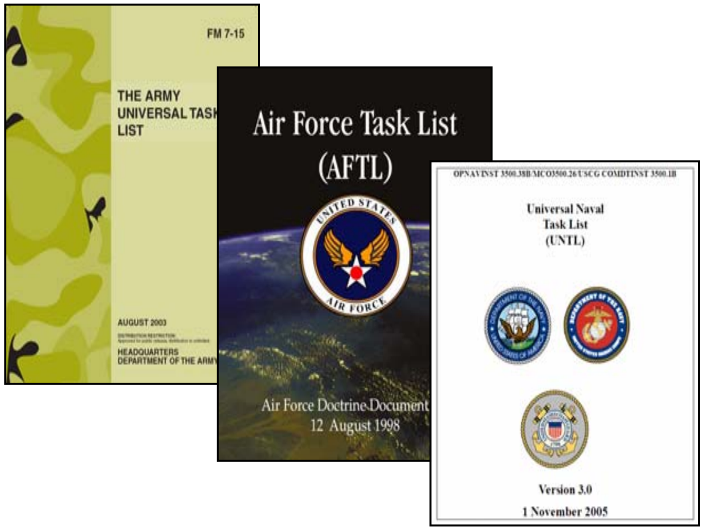


Vans on Van Pad



Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning





Mr J.D. Carpenter
Senior Military Analyst
AVW Technologies, Inc.

Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning

Outline

- Introduction/Background
- Missions, Operations, Tasks, and Task Lists
- Describing a Method
- Lessons Learned

Planning Meaningful Operational Tests

DOT&E Priorities

OFFICE OF THE SECRETARY OF DEFENSE
1700 DEFENSE PENTAGON
WASHINGTON, DC 20301-1700

OPERATIONAL TEST AND EVALUATION

October 23, 2006

MEMORANDUM FOR DOT&E STAFF

SUBJECT: DOT&E Priorities

In my short time here, it has become clear to me that DOT&E does exceptionally fine work to support the warfighters. I hope to build upon that reputation and establish an environment where each of you can continue to excel in our mutual effort to improve the nation's military capability. As we work together, I want you to understand my general philosophy toward operational and live fire testing and evaluation, as well as my priorities for DOT&E.

General Philosophy:

I believe we must provide the Secretary of Defense and Congress, as well as other decision makers, with timely and objective evaluations and assessments of our weapon systems. Equally important, we have to provide commanders in the field with information about systems before they must rely on those systems in combat. I believe those evaluations should start early and that they contribute most to the warfighters when they identify system capabilities, which when integrated into the Joint force, enhance that force's ability to accomplish its missions. On the other hand, we must also identify system characteristics that may limit accomplishment of those missions or adversely affect life-cycle suitability.

Priorities: Consistent with the above philosophy, I want to focus on the following priorities:

- Ensure the professional development of DOT&E personnel. We must ensure that our people are well trained and prepared to meet the challenges presented by the evolving acquisition and testing environments.
- Provide timely performance information to the warfighters. Given the current strategic and operational environments, the acquisition process is changing and the test community must adapt to those changes. While DOT&E must continue to support full rate ***production*** decisions, we must also be able to provide decision makers with assessments that help them make informed ***fielding*** decisions when systems are fielded for operational use prior to the full rate production decision. We must also assist the OTAs in ensuring our Joint warfighters and commanders are aware of system capabilities and limitations when systems are fielded early. I believe these objectives are consistent with the congressional intent of the FY07 National Defense Authorization Act.
- Improve suitability. My impression is that systems generally seem to be doing well in enhancing mission effectiveness. The suitability of systems, on the other hand, requires additional focus. Effectiveness and suitability are not conflicting concepts if both are considered and assessed early in the design and developmental processes. DOT&E must focus the test community's effort to identify failure modes and impacts early in these processes. It is far more important for a system to be effective when it is needed than when it is available.
- Enhance operational realism in early tests, including DT. With changes in the acquisition process focusing on developing and fielding systems on a shorter timeline, I see a need to incorporate operational realism into developmental testing to gain operational insights as early as possible. I believe there is more that can be done to synchronize DT and OT to enhance the discovery process during DT, eliminate surprises in OT, and shorten the overall development cycle.
- Facilitate adequate OT resources, including adequate resources for the OTAs. It is important that adequate resources are devoted to test and evaluation within the Department of Defense. There must be adequate resources dedicated to OT&E to ensure test adequacy to determine operational effectiveness and suitability. I will champion the effort to ensure that we and the OTAs have adequate resources, including budget and personnel, to perform our Title 10 responsibilities.

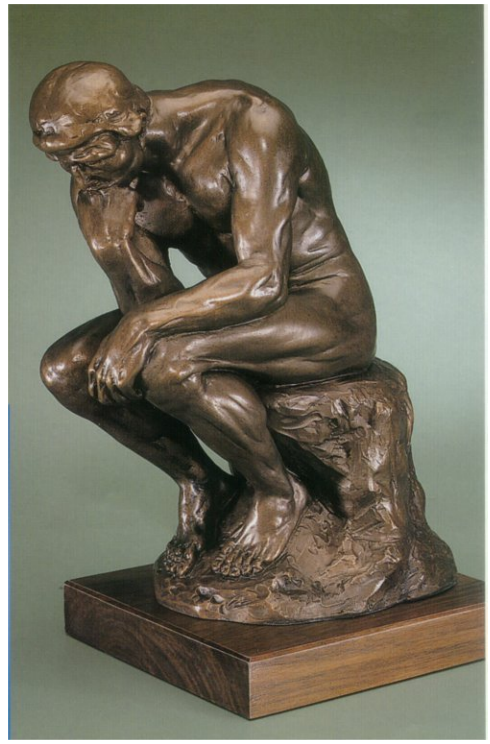
While these priorities do not necessarily encompass all that we do, I believe that their implementation will move us along the path of continuing excellence. I welcome your comments on how these priorities can be improved because it is important that they become "our" priorities.

Dr. Charles E. McQueary
Director

- Provide timely performance information to the warfighters
- **<u>Improve suitability</u>**
- **<u>Enhance operational realism in early test, including DT</u>**
- Facilitate adequate OT resources, including adequate resources for the OTAs

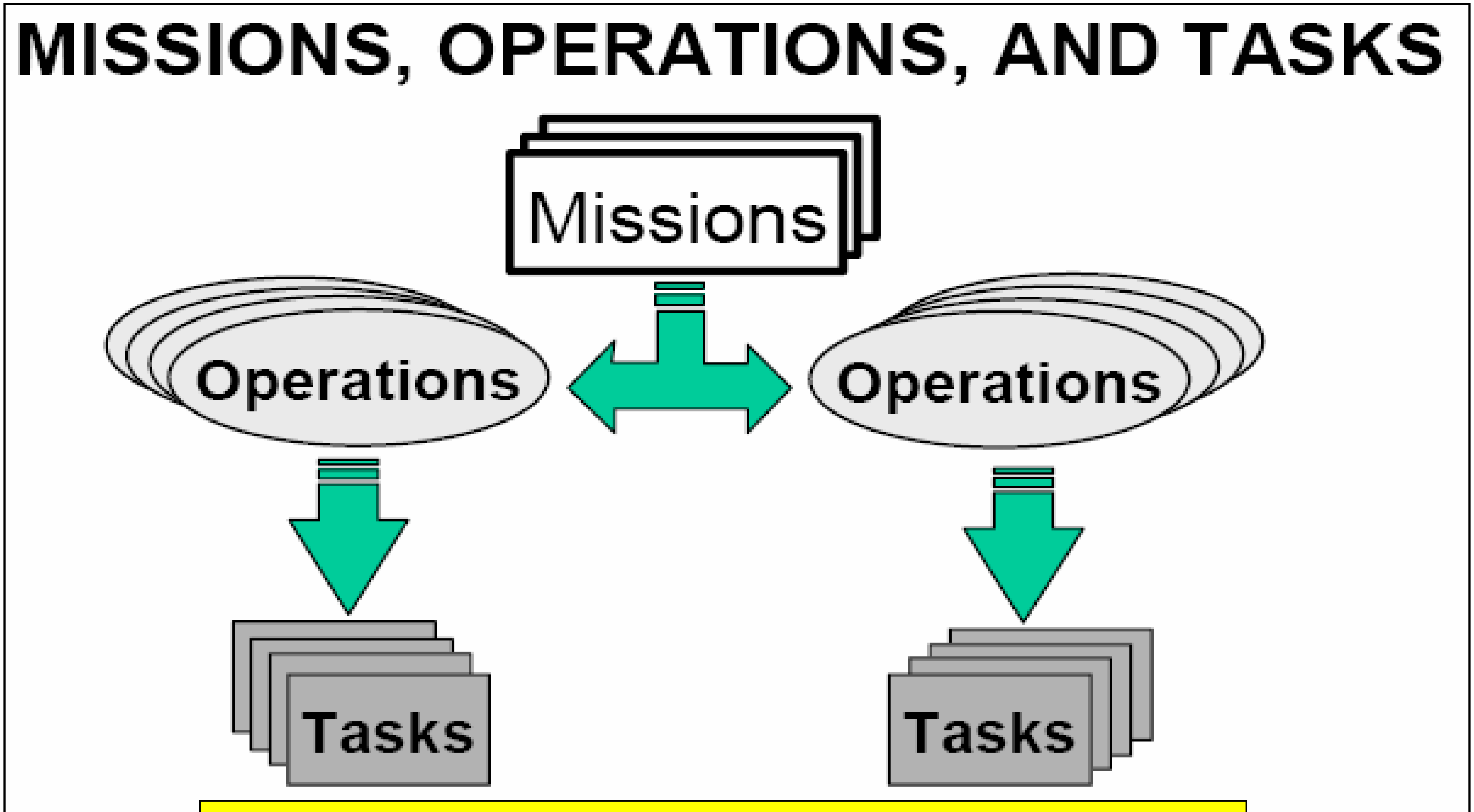
Leadership recognizes the real need for operational realism in early testing

So then, how do you inject realism into operational test planning?



We believe one good option is to go to the source - UJTLs

Relationship of Missions, Operations and Tasks



Our focus is on the operational and tactical level tasks

Extracted from CJCSM 3500.04D

Other Important Terms

- **Mission Task**
- ***Mission Essential Task (MET)***
- **Conditions**
- **Standards or MOEs**
- ***Supporting & Enabling Tasks***
- ***TYPES OF TASK LISTS***
- ***Mission Essential Task Lists (METL)***
- ***Joint Mission Essential Task List (JMETL)***

USES of UJTLs & AMETLs.

The Joint and Service task lists (both UJTLs and AMETLs) may be used to support education and training, test and evaluation, operational planning, and readiness assessment.

Air Force Task List

PROVIDE AIR AND SPACE SUPERIORITY AFT 1

- Provide Counterair Capabilities — AFT 1.1
- Provide Counterspace Capabilities — AFT 1.2

PROVIDE PRECISION ENGAGEMENT AFT 2

- Provide Lethal Precision Engagement Capabilities — AFT 2.1
- Provide Nonlethal Precision Engagement Capabilities — AFT 2.2
- Provide CSAR Capabilities — AFT 2.3

PROVIDE INFORMATION SUPERIORITY AFT 3

- Provide Information Operations Capabilities — AFT 3.1

PROVIDE GLOBAL ATTACK AFT 4

- Provide Strategic Attack Capabilities — AFT 4.1
- Provide Counterland Capabilities — AFT 4.2
- Provide Countersea Capabilities — AFT 4.3
- Provide Special Operations Forces Employment Capabilities — AFT 4.4

PROVIDE RAPID GLOBAL MOBILITY AFT 5

- Provide Airlift Capabilities — AFT 5.1
- Provide Air Refueling Capabilities — AFT 5.2
- Provide Spacelift Capabilities — AFT 5.3
- Provide Air Expeditionary Force (AEF) Capabilities — AFT 5.4

PROVIDE AGILE COMBAT SUPPORT AFT 6

- Provide the Capability to Ready the Force — AFT 6.1
- Provide the Capability to Protect the Force — AFT 6.2
- Provide the Capability to Prepare the Operational Environment — AFT 6.3
- Provide the Capability to Position the Force — AFT 6.4
- Provide the Capability to Employ the Force — AFT 6.5
- Provide the Capability to Sustain the Force — AFT 6.6
- Provide the Capability to Recover the Force — AFT 6.7

PROVIDE COMMAND AND CONTROL AFT 7

- Monitor Global Conditions and Events — AFT 7.1
- Assess Global Conditions and Events — AFT 7.2
- Plan Military Operations — AFT 7.3
- Execute Military Operations — AFT 7.4

Extracted from AFDD 1-1

AFTL Tasks in Relationship to UJTL "Tactical Level of War" Tasks

	TA1 Deploy/ Conduct Maneuver	TA2 Develop Intelligence	TA3 Employ Firepower	TA4 Perform Logistics & Combat Service Support	TA5 Exercise Command & Control	TA6 Protect the Force
Air & Space Superiority	X	X	X			X
Precision Engagement	X	X	X	X	X	X
Information Superiority	X	X	X	X	X	X
Global Attack	X		X			X
Rapid Global Mobility	X	X	X	X		X
Agile Combat Support	X	X	X	X	X	X
Command & Control	X	X	X	X	X	X

Extracted from AFDD 1-1

Army Universal Task List

ART 1.0 Intelligence

- ART 1.1 Provide Support to Situational Understanding
- ART 1.2 Support Strategic Responsiveness
- ART 1.3 Conduct ISR
- ART 1.4 Provide Intelligence Support to Effects

ART 2.0 Maneuver

- ART 2.1 Perform tactical Actions Associated With Force Projection and Deployment
- ART 2.2 Conduct Tactical Maneuver
- ART 2.3 Conduct Tactical Troop Movements
- ART 2.4 Conduct Direct Fires
- ART 2.5 Occupy an Area
- ART 2.6 Employ SERE Techniques

ART 3.0 Fire Support

- ART 3.1 Decide Surface Targets to Attack
- ART 3.2 Detect and Locate Surface Targets
- ART 3.3 Employ Fires to Influence the Will and Destroy, Neutralize or Suppress Enemy Forces

ART 4.0 Air Defense

- ART 4.1 Prepare to Defend Against Air Attack and Aerial Surveillance
- ART 4.2 Process Tactical Aerial Platforms
- ART 4.3 Destroy Aerial Platforms
- ART 4.4 Deny the Enemy Use of Airspace

ART 5.0 Mobility/Countermobility/Survivability

- ART 5.1 Conduct Mobility Operations
- ART 5.2 Conduct Countermobility Operations
- ART 5.3 Conduct Survivability Operations

ART 7.0 Command and Control

- ART 7.1 Establish Command Post Operations
- ART 7.2 Manage Tactical Information
- ART 7.3 Assess the Tactical Situation and Operations
- ART 7.4 Plan tactical Operations Using the MDMP/TLP
- ART 7.5 Prepare for Tactical Operations
- ART 7.6 Execute Tactical Operations
- ART 7.7 Support the Commander's Leadership Responsibilities for Morale, Welfare, and Discipline
- ART 7.8 Conduct Continuous Operations
- ART 7.9 Develop and Implement a Command Safety Program
- ART 7.10 Conduct Public Affairs Operations

ART 6.0 Combat Service Support

- ART 6.1 Provide Supplies
- ART 6.2 Provide Maintenance
- ART 6.3 Provide Transportation Support
- ART 6.4 Provide Sustainment Support
- ART 6.5 Provide Force Health Protection in Global Environment
- ART 6.6 Provide Human Resource Support
- ART 6.7 Provide Finance & Resource Management Services
- ART 6.8 Provide Religious Support
- ART 6.9 Provide Legal Support
- ART 6.10 Provide General Engineer Support
- ART 6.11 Provide Contracting Support
- ART 6.12 Provide Distribution Management
- ART 6.13 Conduct Internment and Resettlement Activities
- ART 6.14 Conduct Civil-Military Operations

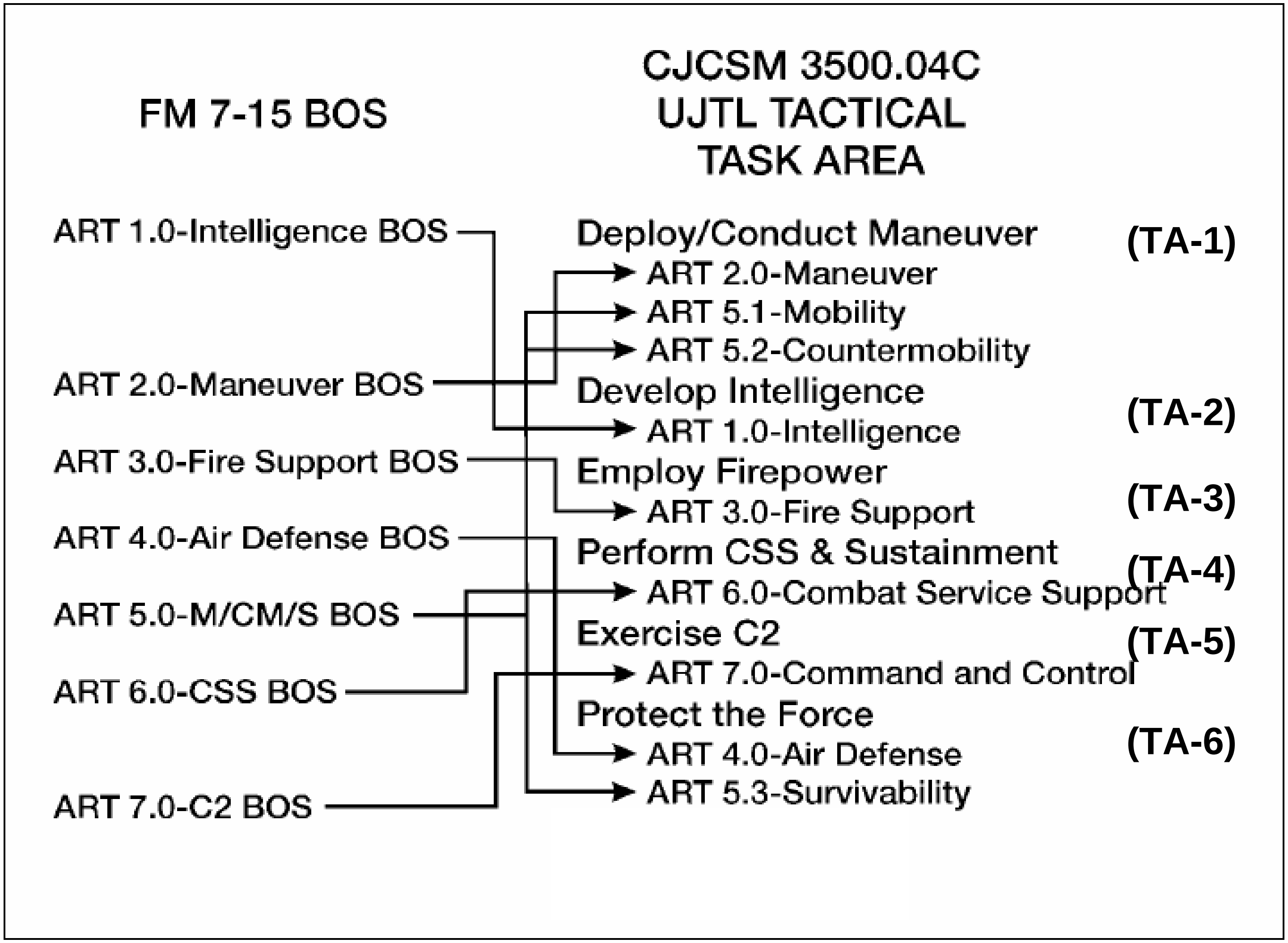
ART 8.0 Conduct Tactical Mission Tasks and Operations

- ART 8.1 Conduct Offensive Operations
- ART 8.2 Conduct Defensive Operations
- ART 8.3 Conduct Stability Operations
- ART 8.4 Conduct Support Operations
- ART 8.5 Conduct Tactical Mission Tasks

Note: ARTs 1-7 constitute the Battlefield Operating System

Generated from FM 7-15

Army Tasks in Relation to UJTL "Tactical Level of War" Tasks



Extracted from FM 7-15

Universal Naval Task List

NTA 1 Deploy/Conduct Maneuver

- NTA 1.1 Move Naval Tactical Forces
- NTA 1.2 Navigate and Close Forces
- NTA 1.3 Maintain Mobility
- NTA 1.4 Conduct Countermobility
- NTA 1.5 Dominate the Operational Area

NTA 2 Develop Intelligence

- NTA 2.1 Plan and Direct Intelligence Operations
- NTA 2.2 Perform Collection Operations and Management
- NTA 2.3 Process and Exploit Collected Information and Intelligence
- NTA 2.4 Conduct Analysis and Produce Intelligence
- NTA 2.5 Disseminate and Integrate Intelligence
- NTA 2.6 Evaluate Intelligence Operations

NTA 3 Employ Firepower

- NTA 3.1 Process Targets
- NTA 3.2 Attack Targets
- NTA 3.3 Conduct Special Weapons Attack

NTA 4 Perform Logistics and Combat Service Support

- NTA 4.1 Arm
- NTA 4.2 Fuel
- NTA 4.3 Repair/Maintain Equipment
- NTA 4.4 Provide Personnel and Personnel Support
- NTA 4.5 Provide Transport Services
- NTA 4.6 Supply the Force
- NTA 4.7 Perform Civil Military Engineering Support
- NTA 4.8 Conduct Civil Affairs in Area
- NTA 4.9 Train Forces and Personnel
- NTA 4.10 Perform Resource Managem ent
- NTA 4.11 Provide Operational Legal Advice
- NTA 4.12 Provide Health Services
- NTA 4.13 Conduct Recovery and Salvage
- NTA 4.14 Provide Support Services

Naval Tactical Tasks Mimic the UJTL "Tactical Level of War" Tasks

NTA 5 Exercise Command and Control

- NTA 5.1 Acquire, Process and Communicate Information and Maintain Status
- NTA 5.2 Analyze and Assess Situation
- NTA 5.3 Determine and Plan Actions and Operations
- NTA 5.4 Direct, Lead and Coordinate Forces
- NTA 5.5 Conduct Information Warfare (IW)
- NTA 5.6 Conduct Acoustic Warfare
- NTA 5.7 Establish a Task Force Headquarters
- NTA 5.8 Provide Public Affairs Services

NTA 6 Protect the Force

- NTA 6.1 Enhance Survivability
- NTA 6.2 Rescue and Recover
- NTA 6.3 Provide Security for Operational Forces and Means
- NTA 6.5 Perform Consequences Management
- NTA 6.6 Provide for Operational Safety of Personnel and Equipment

Generated from OPNAVINST 3500.38B

Why Use UJTL/AMETLs for Operational Test Planning

- "UJTL linkage to capability development processes enhances the identification of joint requirements, capability shortfalls and deficiencies." (Extracted from CJCSM 3500.04D)
- Service task lists capture service doctrine and therefore is an excellent representation of required mission capability.
- Service task lists provide a concise picture of the major activities of a force (provide increased detail on what the force must do to accomplish its mission).
- Service task lists provide all the collective tasks possible for tactical units.

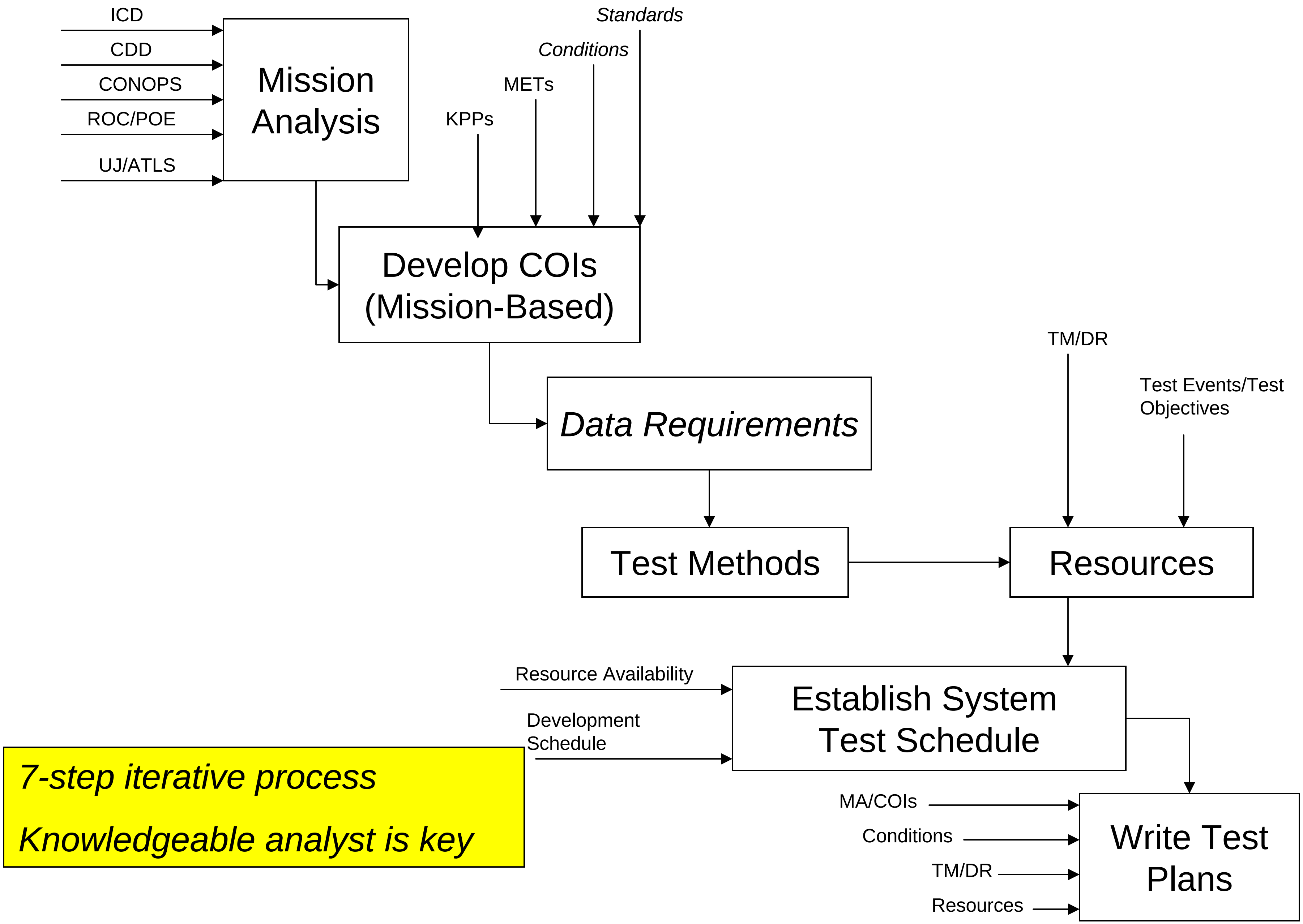
Task lists provide a basis for mission analysis, which identifies those "essential" tasks necessary for mission success.

So What?

- Using mission requirements to assess the capability new systems will provide is a logical “next step”.
- The ability to define capabilities-based requirements early in the acquisition process and to make better use of combined/integrated testing facilitates program manager’s delivery of effective and suitable systems to the warfighter with greater potential for reduced schedule and total ownership cost
- Defining the capabilities-based requirements early on in a program also facilitates early test resource determination (i.e. facilities, test equipment, test objectives, data requirements, etc.) and more accurate cost projection

This methodology capitalizes on the overarching direction already in place within the DoD 5000 and service acquisition regulations.

Mission-Based System Operational Test Planning Process



Lessons Learned

- Using the Universal Joint Task List/Service Task Lists to support mission analysis has proven useful in deriving mission essential tasks from which to develop mission-based COIs.
- This methodology can be applied to any developmental system in any service.
- This methodology can be used regardless of whether or not combined/integrated testing is used
- This methodology would also prove useful for the developmental test community.
- Use of a database to manage data generated during this process is key to success.
- An experienced analyst is worth his weight in gold.
- DoD policy guidance enhancement is required to fully optimize this methodology for integrated testing.

Using Mission Essential Task Lists as a Basis for Mission-Based Operational Test Planning

Questions?

Mr. J.D. Carpenter

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Back-up Slides

Talent and genius operate outside the rules, and theory conflicts with practice.

Major General Carl von Clausewitz
On War

Organization of Conditions for Joint/Agency Tasks

1.0 PHYSICAL ENVIRONMENT

1.1 Land
1.2 Sea
1.3 Air
1.4 Space

2.0 MILITARY ENVIRONMENT

2.1 Mission
2.2 Forces
2.3 Command, Control, & Communications
2.4 Intelligence
2.5 Deployment, Movement, & Maneuver
2.6 Combat
2.7 Protection
2.8 Sustainment
2.9 Threat
2.10 Conflict

3.0 CIVIL ENVIRONMENT

3.1 Political Policies
3.2 Culture
3.3 Economy

Match tasks to conditions

(These categories as the basis for defining service-specific conditions)

Extracted from CJCSM 3500.04D

What is JCIDS

Ensures the joint force has the capabilities to perform across the range of military operations

Is a primary interface to the DoD acquisition system

Implements an integrated process to guide new capabilities development

A key linkage on how the future joint force will fight

Provides the analytic baselines to support studies to inform capability development

Leverages expertise to identify improvements to existing capabilities and to develop new warfighting capabilities

JCIDS ***along with the*** *Defense Acquisition System and the Planning, Programming, Budgeting and Execution processes form the principal DOD decision support processes for transforming the military forces to support the national military strategy and the defense strategy*

Describing the Process

- **Conduct mission analysis** and identify specified and implied tasks contained in the guidance (ICD, CDD, CONOPS, etc.)
  - **IDENTIFY THE MET** – This will require thorough analyst knowledge of the system or OTA determination
  - **DESCRIBE CONDITIONS** - Conditions are used in the METL development process to express variables of the environment that affect task performance.
  - **ESTABLISH STANDARDS -** The final step in developing the MET involves selecting or developing performance standards consistent with the commander's intent and CONOPs for a mission.
  - We found it useful to develop an Access database (or any other database product of your liking) that contains tasks and metrics matched from the Joint and Service task lists.
  - A database can be used to output tables that link tasks to CDD attributes as well as other references.

- **Develop COIs** (mission-based from METs)
  - The UJTL is used to help frame COIs in terms of the Joint and Composite Warfighter. The UJTL also helps define relevant Joint operational measures and conditions for the system under test.

- **Determine data required** to assess effectiveness and suitability of the system under test
- **Define test methods** to obtain required data
- **Determine required resources**
- **Establish a test schedule**
- **Write the test plan**
  - A database will prove useful not only in maintaining the linkage between tasks, metrics, test methods, data requirements and resources but can also provide the framework for required test plans.

AVW uses this methodology in support of its clients.

Demonstration

- Process applied to System XX

Available at AVW TECHNOLOGIES, INC. Display Table

BOMBARDIER

AMSAA
Excellence in Analysis

A Successfully Implemented Coordinated Subsystem Reliability Growth Planning Approach

Briefing To:

23rd Annual National Test & Evaluation Conference

Tuesday, 13 March 2007

Louis Chénard (CDN)
Bombardier Aerospace

Paul Ellner (US)
Research, Development & Engineering Command/
Army Materiel Systems Analysis Activity (AMSAA)

Jean-Louis Pérée (F)
Bombardier Transportation

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Topics

AMSAA Excellence in Analysis

- *Reliability Growth Planning Model SSPLAN*
  - Overview
  - Principal Benefits and Features
  - Model Inputs and Outputs
  - Procedure used to Generate Model Outputs
- *Bombardier Applications*
  - Bombardier Overview
  - Problem Statement / Opportunity
  - Reliability Maturation Model
  - New Reliability Growth (NRG II) Model Objectives
  - Railway example of implementation process
  - Interactions between basic elements of reliability process
  - Summary of NRG II Benefits

SSPLAN Overview

- Reliability Growth Planning Model based on system level reliability objective (mean test duration between failure, MTBF) and coordinated subsystem growth program inputs.
- Applies to systems composed of a series of subsystems that independently generate failures.
- Can accommodate a mixture of growth and non-growth subsystems.
- Measure of test duration, t , is continuous (e.g., time, distance).
- Assumes for each growth subsystem i, the number of failures that occur in test interval [0,t], $N_i(t)$, is governed by a nonhomogeneous Poisson process (NHPP) with a power law mean value function $\lambda_i t^{\beta_i}$ assumed at system level in U.S. MIL-HDBK-189.
- Developed by AMSAA and documented in AMSAA Reliability Growth Guide (Technical Report No. TR-652, Sept. 2000)

Principal Benefits and Features

- **Helps construct a set of subsystem planning curves with associated subsystem test durations and target MTBFs**
  - **that are consistent with system reliability objective and growth subsystem reliability allocations**
  - **whose achievability can be gauged by past experience**

- **Subsystem planning curves and test durations have property that if realized during developmental test program, with a *specified probability*, subsystem test data would provide a *specified level of assurance* that system reliability objective is met.**

- **Subsystem planning curves support decision process with respect to allocation of test resources**
  - **prior to test program**
  - **during testing with regard to reallocation to address subsystem reliability deficiencies**
    - ✓ **can provide objective basis for prioritizing subsystem corrective action efforts**

- **System and associated subsystem planning curves serve as benchmarks against which reliability improvement can be measured**
  - **highlights to program management and customers assessed reliability versus reliability goals at program milestones**
    - ✓ **at system and subsystem levels**

Model Inputs & Outputs

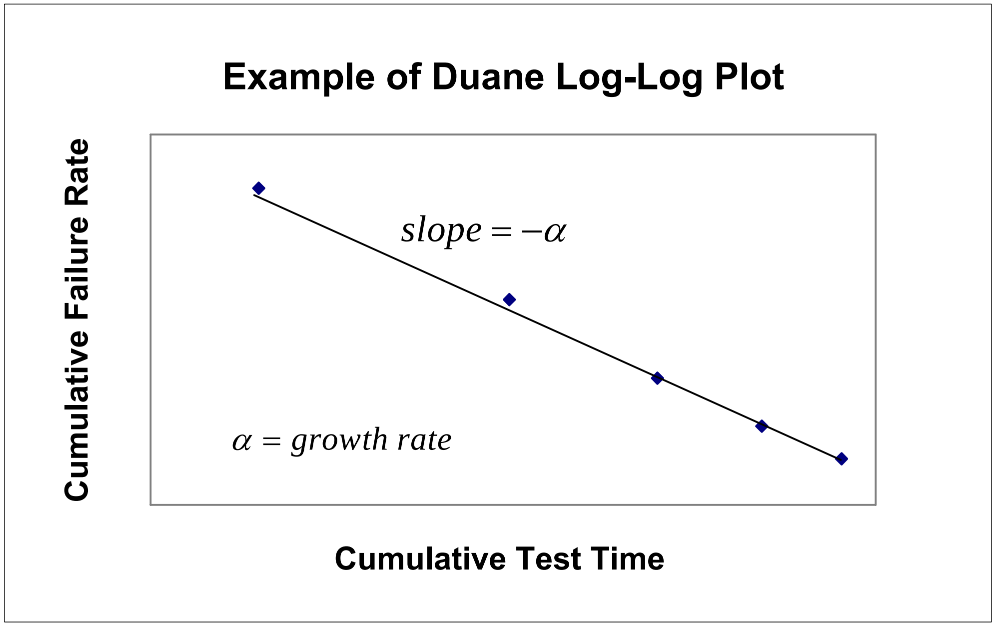
- ***<u>System Level Inputs</u>***
  - System MTBF objective, $M_{obj,Sys}$
  - Statistical confidence level γ for lower confidence bound LCB_{γ} on achieved system MTBF
  - Specified probability p_0 that subsystem test data would yield a value of LCB_{γ} that meets or exceeds $M_{obj,Sys}$ if subsystems grow in accordance to planning curves for planned test durations
    - ✓ γ is the *specified level of assurance*
    - ✓ p_0 is the *specified probability* that assurance level would be realized under growth assumption
- ***<u>System Level Output</u>***
  - System MTBF target , $M_{targ,Sys}$
    - ✓ Reciprocal of sum of subsystem target failure intensities
    - ✓ $M_{targ,Sys} > M_{obj,Sys}$ for practical values of γ and p_0

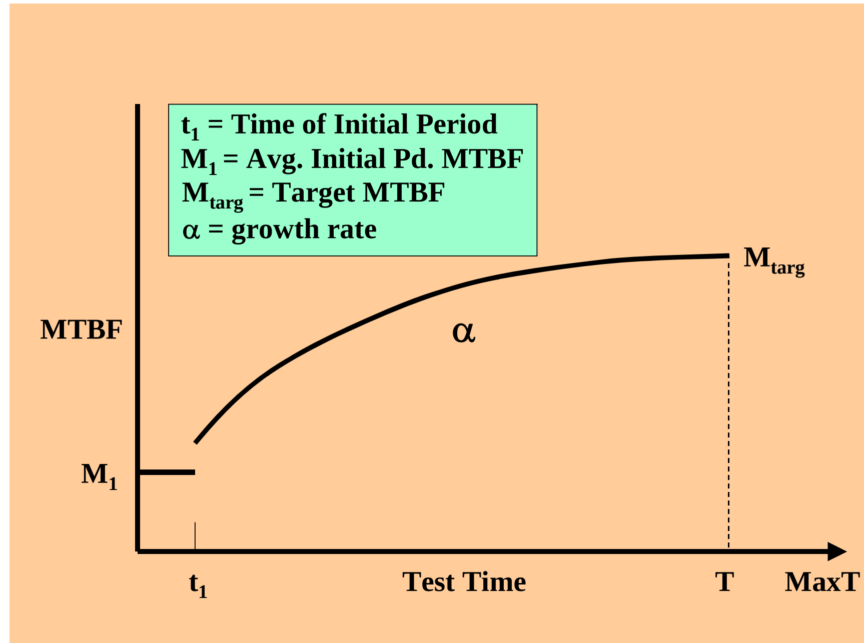
Model Inputs & Outputs

- ***Growth Subsystem Inputs***
  - Growth rate α_i
    - ✓ Negative of slope on log-log plot of expected cumulative failure intensity versus cumulative test duration
  - Initial test period $t_{1,i}$
    - ✓ Growth is planned to commence by the end of initial test period
  - Average MTBF expected over initial test period, $M_{1,i}$
  - Allocation fraction, a_i , of growth subsystem portion of target system failure intensity to growth subsystem i
    - ✓ If all subsystems have growth programs, target failure intensity for subsystem satisfies $\lambda_{targ,i} = a_i \cdot \lambda_{targ,Sys}$
  - Maximum subsystem test duration

- ***Growth Subsystem Outputs***
  - Test duration for subsystem i, T_i
  - Target MTBF for subsystem i, $M_{targ,i}$
  - Expected number of subsystem failures in test, $E(N_i) = T_i / \{(1-\alpha_i) \cdot M_{targ,i}\}$

Duane Plot and Subsystem Idealized Reliability Growth Curve





<ins>*Duane Postulate*</ins>: If changes to improve reliability are incorporated into the design of a system under development, then on a log-log plot, the graph of cumulative failure rate versus cumulative test time tends to exhibit a linear relationship (Duane, 1964).

Outline of Procedure to Obtain Subsystem Test Durations (case where all subsystems are growth subsystems)

- $N_i(t)$ is a NHPP with rate of occurrence function $\rho_i(t)$
  - $\rho_i(t) = \lambda_i \beta_i t^{\beta_i -1}$ where $\beta_i = 1-\alpha_i$ and $\lambda_i = t_{1,i}^{\alpha_i} / M_{1,i}$ for growth subsystem i
- Steps
  - Use trial value $M_{targ,Sys}$ to calculate $\lambda_{targ,i} = a_i \cdot \lambda_{targ,Sys}$
  - Obtain trial value T_i by inverting eq. $\lambda_{targ,i} = \rho_i(T_i)$
  - For each growth subsystem i simulate NHPP from 0 to T_i
  - Calculate pseudo demo. test no. of failures $n_{D,i} = n_i /2$ & time $T_{D,i} = T_i / (2\beta_{est,i})$
    - ✓ $\beta_{est,i}$ is max. likelihood estimate of β_i from simulated growth test data.
    - ✓ Equate point estimate and LCB on $M_{targ,i}$ from pseudo demo. data to estimates from growth data to obtain pseudo demo. test data.
  - Combine subsystem pseudo demo. data to obtain approximate LCB_γ on $M_{targ,Sys}$
    - ✓ Applied Lindström – Madden method adapted for continuous test duration.
    - ✓ Could use other methods for combining pseudo demonstration test data.
  - Repeat last 3 steps prescribed no. of times to estimate Prob ($LCB_\gamma \geq M_{obj,Sys}$)
  - If estimated probability is close to p_0 stop - the current trial T_i are chosen as the subsystem test durations ; otherwise adjust $M_{targ,Sys}$ and repeat above steps.

AEROSPACE & RAILWAY INDUSTRIES APPLICATION

A Successfully Implemented Coordinated Subsystem Reliability Growth Planning Approach

Bombardier's Implementation/Customization of the SSPLAN –

New Reliability Growth (NRG II)

Company Overview

- Corporate office based in Montréal, Canada
- Workforce of some 55,800 people worldwide as at January 31, 2006
- Revenues of $14.7 billion for fiscal year ended January 31, 2006
- More than 94% of revenues coming from foreign markets
- Listed on the Toronto Stock Exchange (BBD)

BOMBARDIER

The focus of Bombardier Inc. is based on two pillars

Transportation

45% of total Revenues

Annual Revenues in (2005/2006):
US$6.6bn

Aerospace

55% of total Revenues

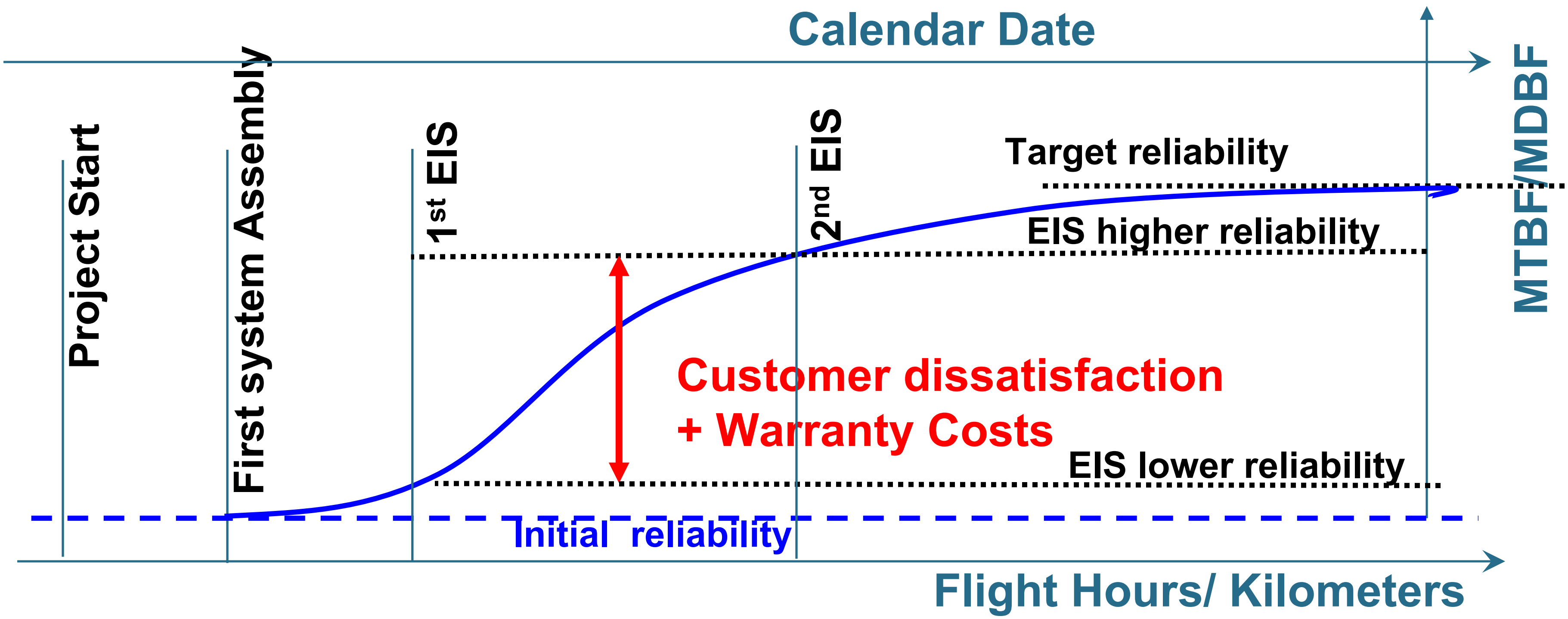
Annual Revenues in (2005/2006):
US$8.1bn

*Figures for the year ending January 31, 2006

Problem Statement / Opportunity

- **Problem Statement**
  - Warranty costs and customer dissatisfaction
  - Weakness in the process to predict, optimize and govern the product reliability in order to meet Entry into Service and in-service performance.
- **Opportunity to raise reliability performance**
  - Insure reliability performance meet commitments as per schedule
  - Reduce Warranty cost
  - Model Life Cycle Cost
  - Improve Maintenance Program
  - Highlight to senior management reliability progress of all subsystems
  - Prioritization of corrective actions

Reliability Maturation Model



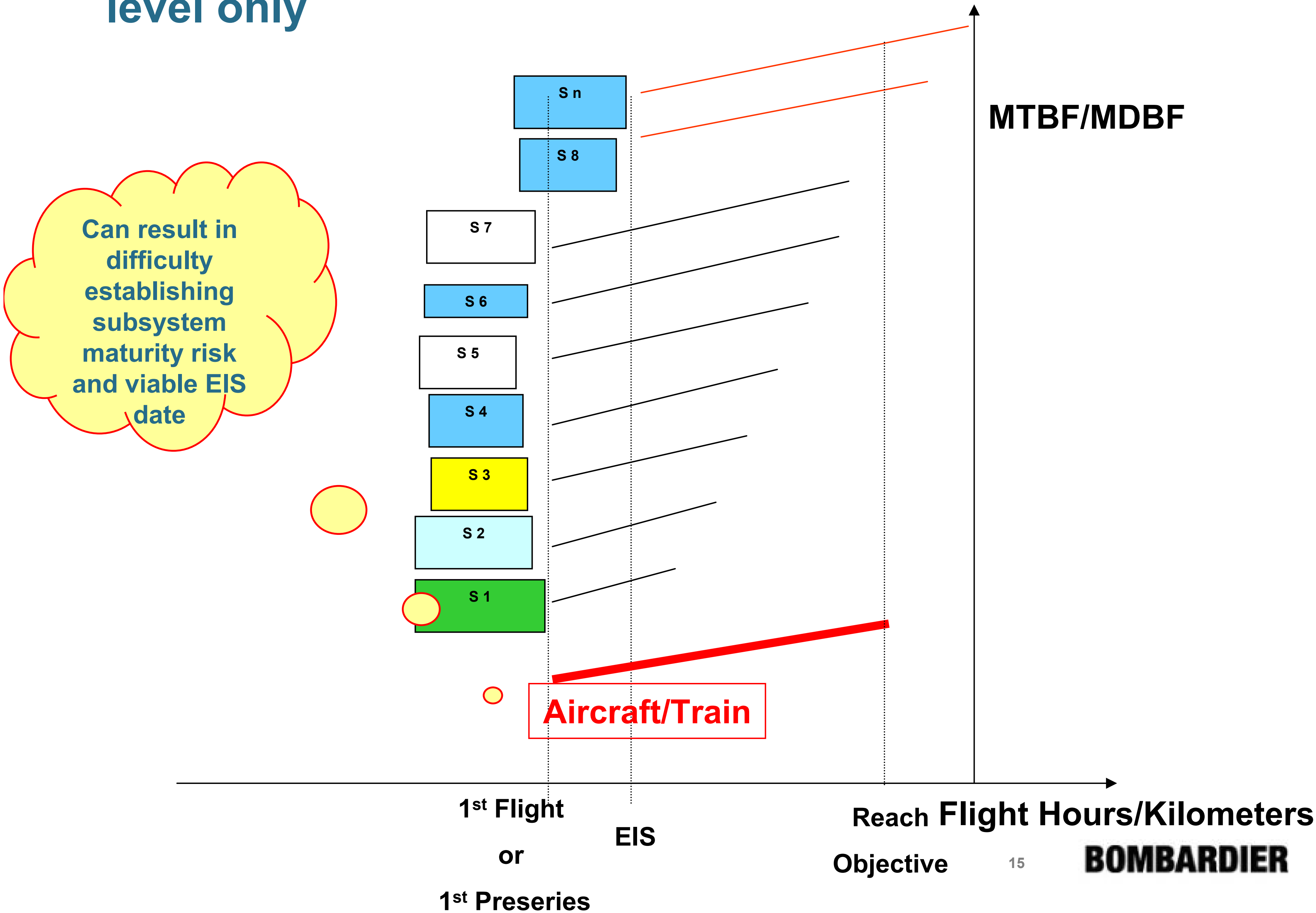
- **Potential shortfalls in managing reliability**
  - System Reliability measurements start too Late.
  - No Prediction of reliability at Entry Into Service(EIS).
  - No Proactive action to ensure that EIS reliability will be met.
- **Need reliability growth program plan to conduct trade-off analysis between EIS calendar date and EIS expected reliability.**
- **Need to measure against program plan.**

Address in growth plan

New Reliability Growth (NRG II) Model Objectives

- **Predict Reliability Maturation**
  - Based on past performance by system and supplier
  - Include reliability growth from the start of testing
  - Supports spares contingency requirements
- **Optimize lifecycle costs linked to reliability**
  - Perform trade studies between increasing testing and fixing issues in the field
  - Allow analysis between EIS calendar date and EIS expected reliability
  - Optimize maintenance program
- **Govern Reliability Growth and issues from day one**
  - Set up a framework to compare actual reliability to planned reliability
  - Comparison provides basis for efficient proactive management with regard to failure mode mitigation
- **Utilize coordinated subsystem reliability growth strategy**

Classic growth – Planning and monitoring at system level only



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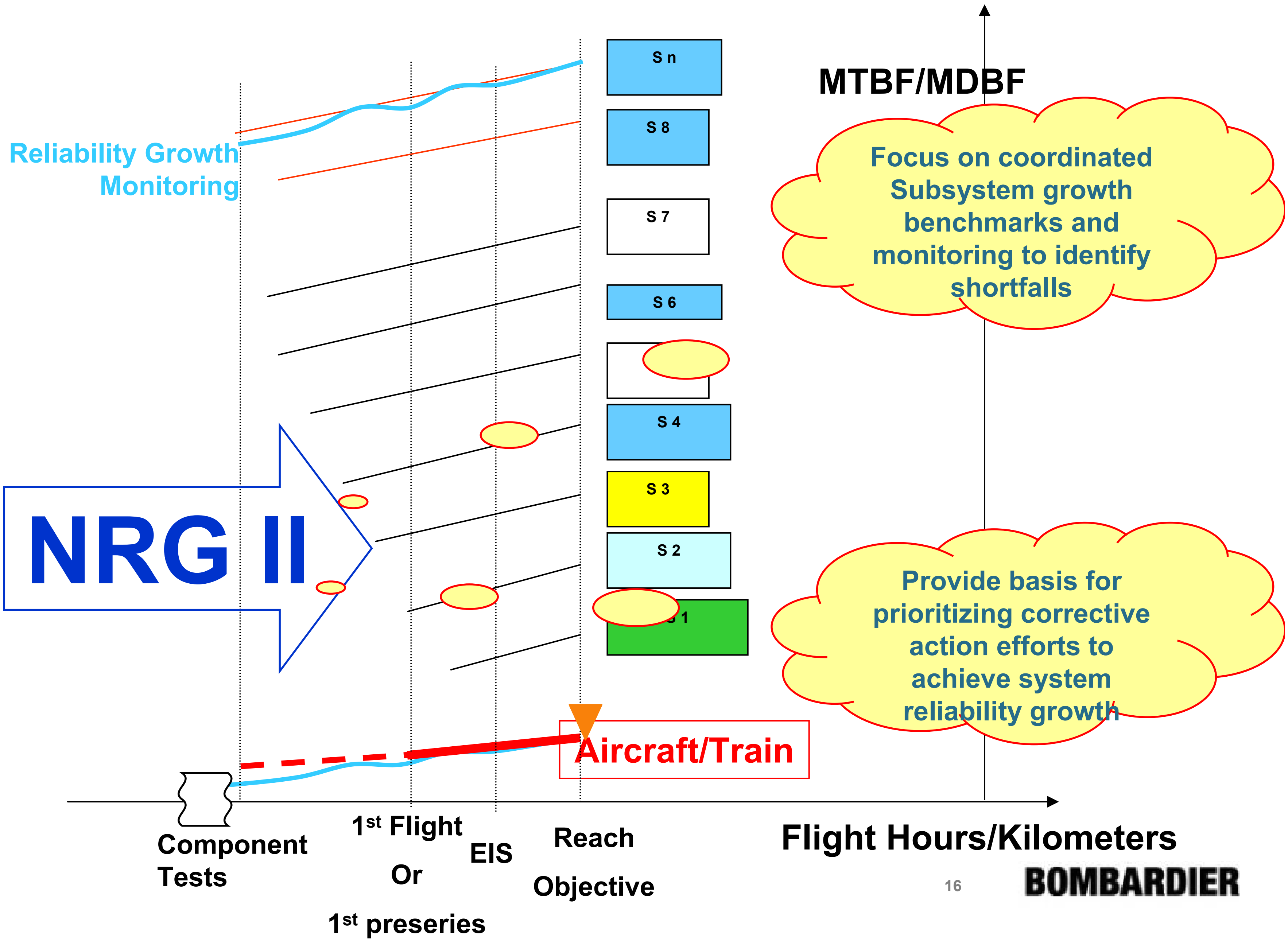
NRG II Approach



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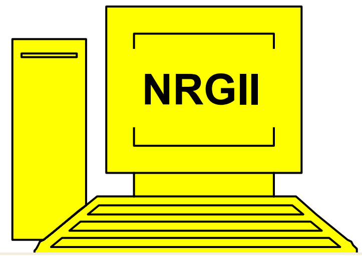
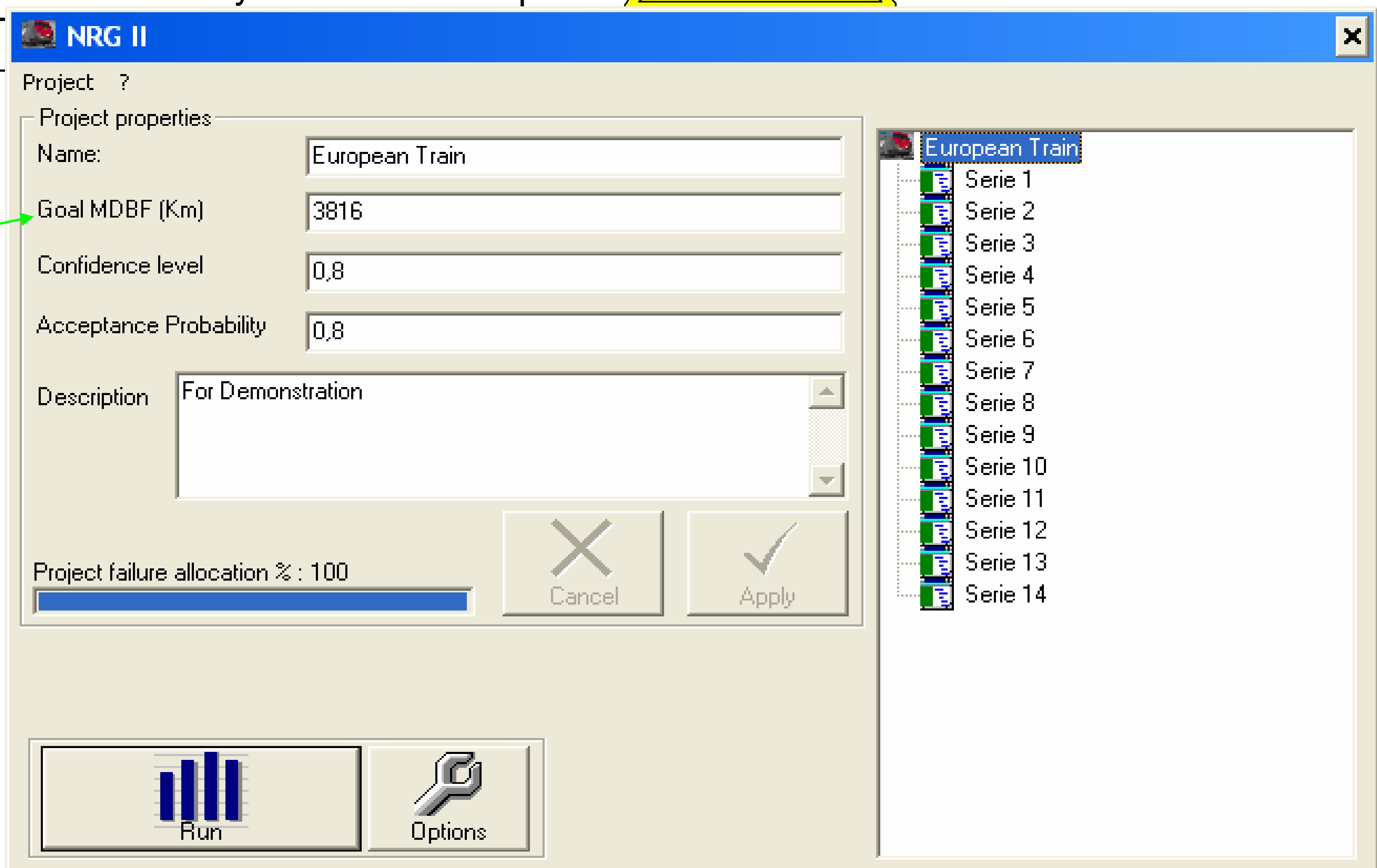
Reliability Growth : method NRG II

- Name of the Product
- MDBF or MTBF Objective (Contractual)
- Confidence Level
- Acceptance Probability
- List of all Main Subsystems

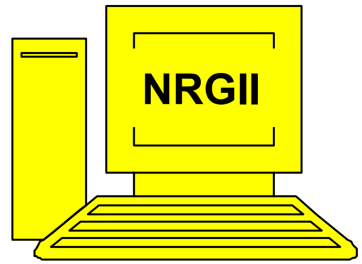


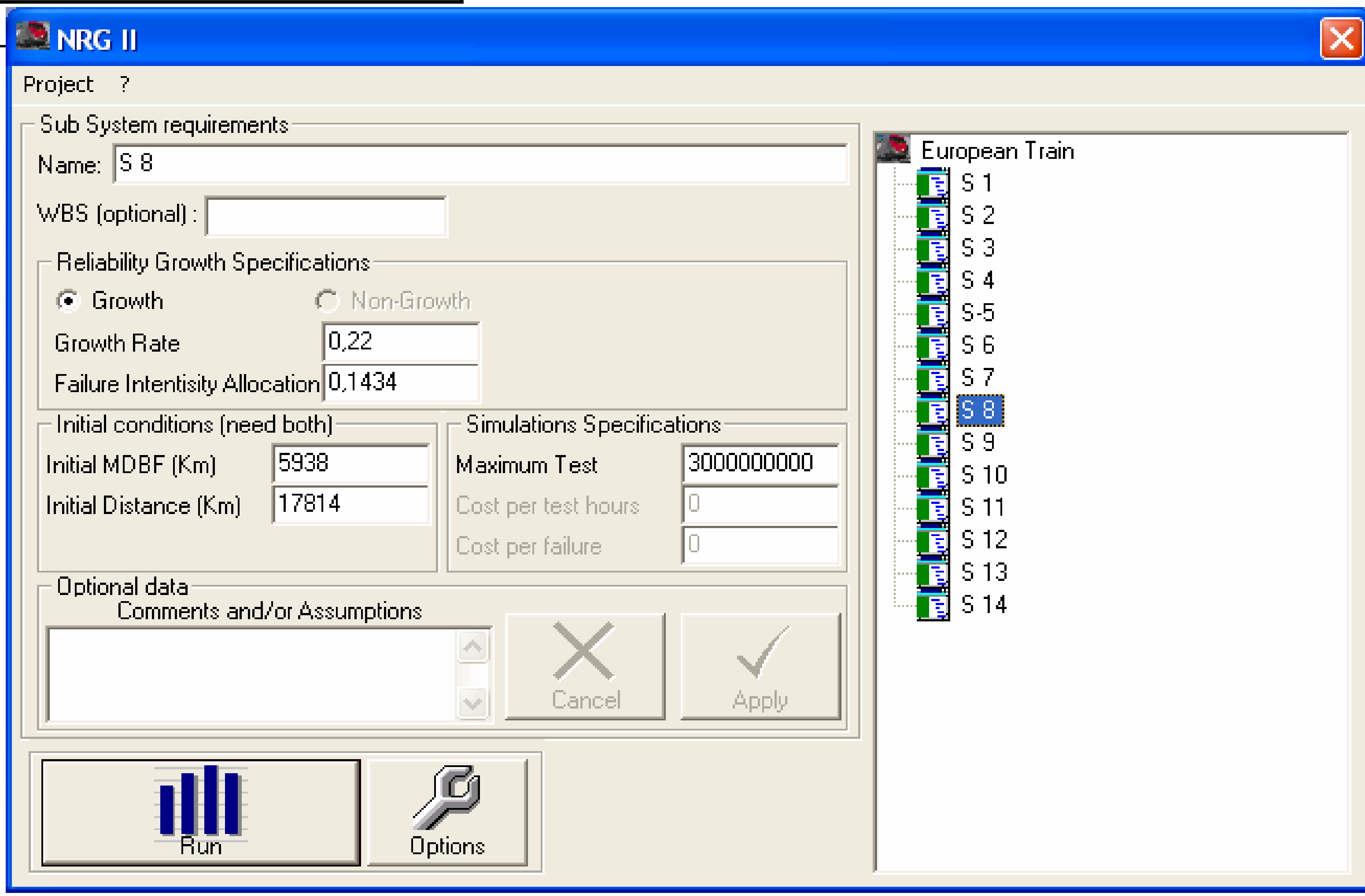
Objective



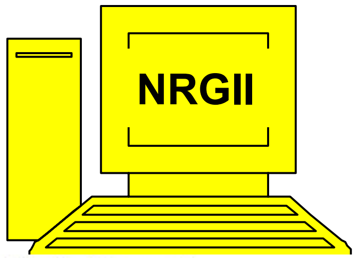
Reliability Growth : method NRG II

- Growth rate alpha
- Failure intensity allocation
- Initial MDBF
- Initial Test Distance
- Maximum Test





Reliability Growth : method NRG II



Per Subsystem:

- Number of Failures
- Total test Distance
- Final MDBF

For the Product:

- Computed Target MDBF

Project	File Name : 2007_02_13_European Train #3				
Name	Comments and/or Assumption	Objective MDBF (Km)	Confidence level	Probability of acceptance	Number of subsystems
European Train	For Demonstration	3816	0.8	0.8	14

Sub-systems

Name	G/N	Alpha	Initial conditions: Initial MDBF (Km)	Initial conditions: Initial Distance	Maximum Distance	MDBF (Km) at system objective	Failure Allocation	Expected failures	Total test Distance	Final MDBF (Km)
S 1	Growth	0,39	311,509	934,528	3000000000	1,413,333	0.0027	**17.64**	**17,055,812**	**1,585,039**
S 2	Growth	0,19	21,000	65,000	3000000000	50,543	0.0755	**86.89**	**3,989,576**	**56,684**
S 3	Growth	0,2	22,035	66,105	3000000000	85,369	0.0447	**437.94**	**33,542,866**	**95,741**
S 4	Growth	0,22	6,113	18,338	3000000000	27,394	0.1393	**380.71**	**9,123,000**	**30,722**
S-5	Growth	0,19	25,435	76,500	3000000000	47,522	0.0803	**28.68**	**1,238,304**	**53,295**
S 6	Growth	0,21	33,677	101,030	3000000000	150,830	0.0253	**535.68**	**71,584,125**	**169,154**
S 7	Growth	0,2	33,456	111,457	3000000000	70,667	0.054	**42.97**	**2,724,189**	**79,252**
S 8	Growth	0,22	5,938	17,814	3000000000	26,611	0.1434	**380.78**	**8,863,814**	**29,844**
S 9	Growth	0,23	3,787	11,362	3000000000	16,975	0.2248	**278.63**	**4,084,317**	**19,037**
S 10	Growth	0,19	35,000	105,000	3000000000	63,920	0.0597	**25.96**	**1,507,564**	**71,685**
S 11	Growth	0,4	578,518	1,735,553	3000000000	2,544,000	0.0015	**15.27**	**26,139,970**	**2,853,071**
S 12	Growth	0,24	7,454	22,363	3000000000	33,415	0.1142	**209.24**	**5,959,427**	**37,475**
S 13	Growth	0,2	26,997	80,922	3000000000	120,759	0.0316	**777.53**	**84,240,787**	**135,431**
S 14	Growth	0,37	279,284	837,853	3000000000	1,272,000	0.003	**21.95**	**19,724,117**	**1,426,535**

System

Epsilon	Number of iterations	Computed probability of acceptance	Computed target MDBF (Km)
	500	0.8	4280

Output

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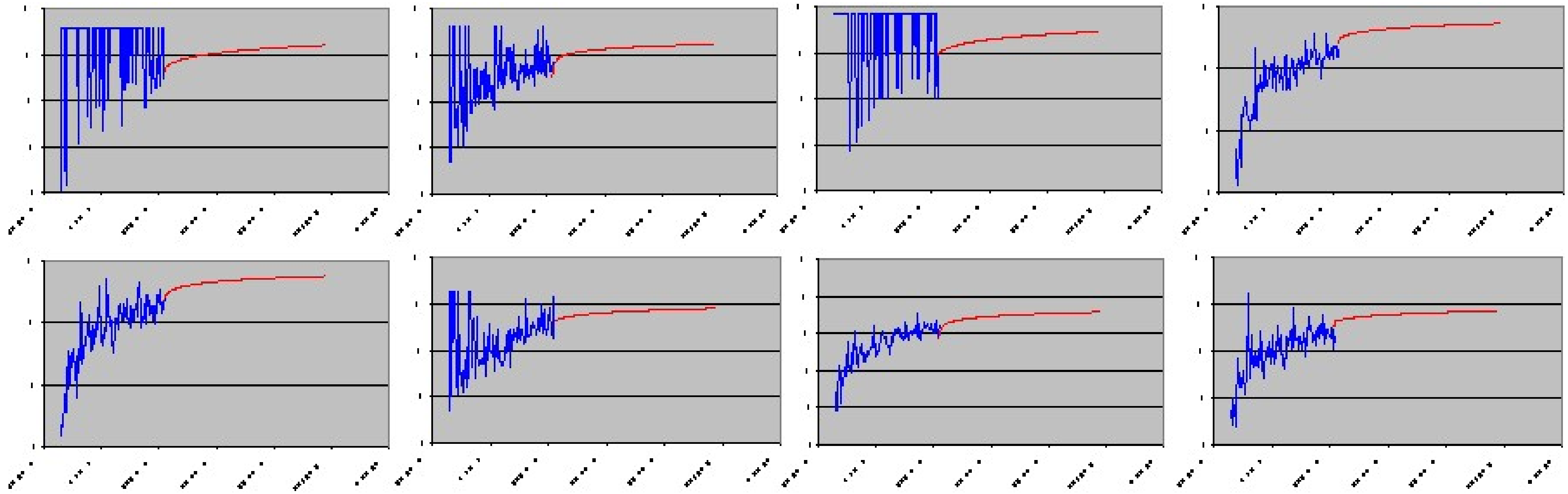
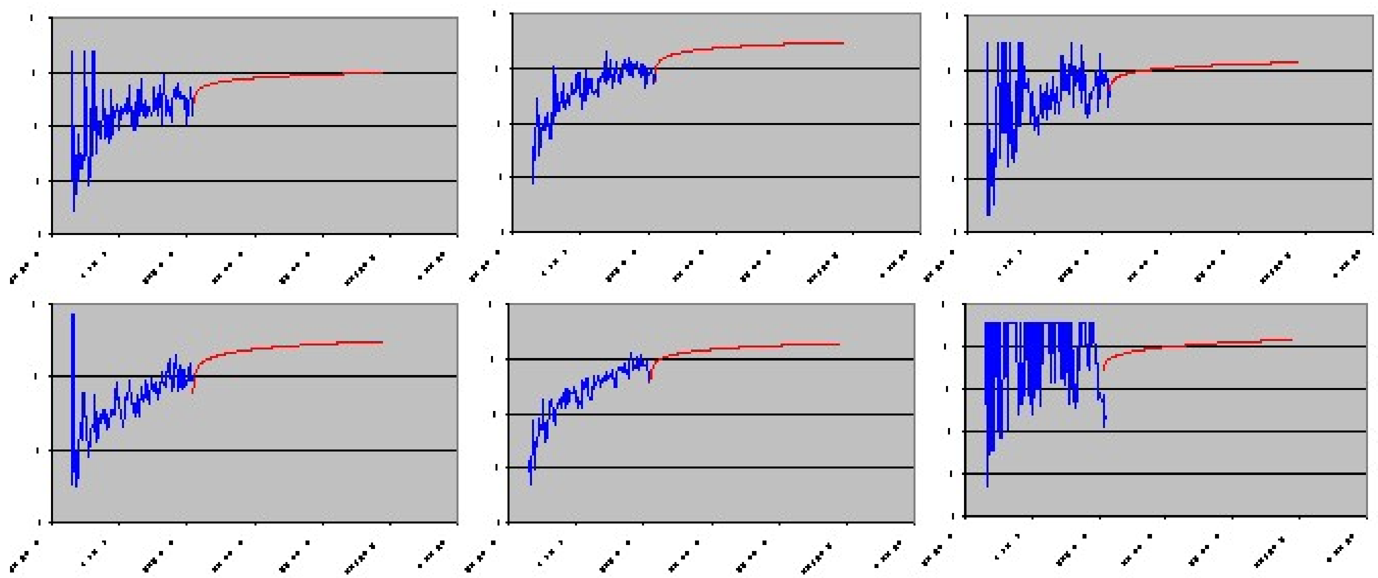
Example of Reliability Growth monitoring of initial subsystem MDBF's for a Product composed of 14 subsystems





NRG II Method

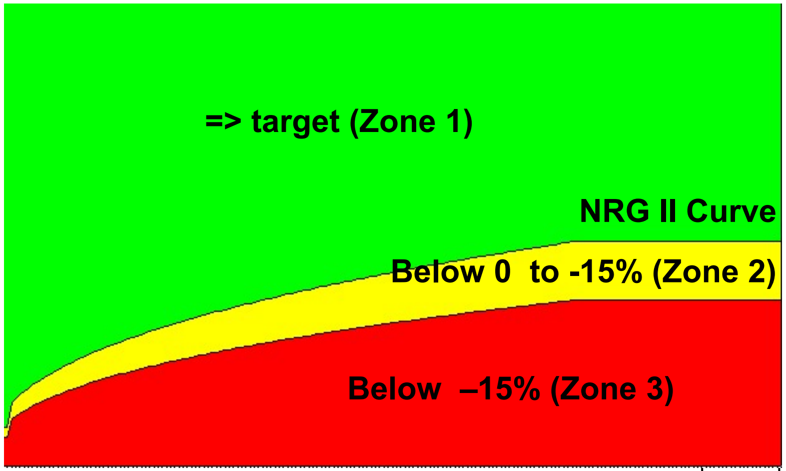
Using event recording per period versus Target on benchmark curve

Establishing priority of corrective actions

Life Cycle Cost

Zone	% measured LCC exceeds target LCC
1	Less 5%
2	5 to 15%
3	15% and up

Reliability performance



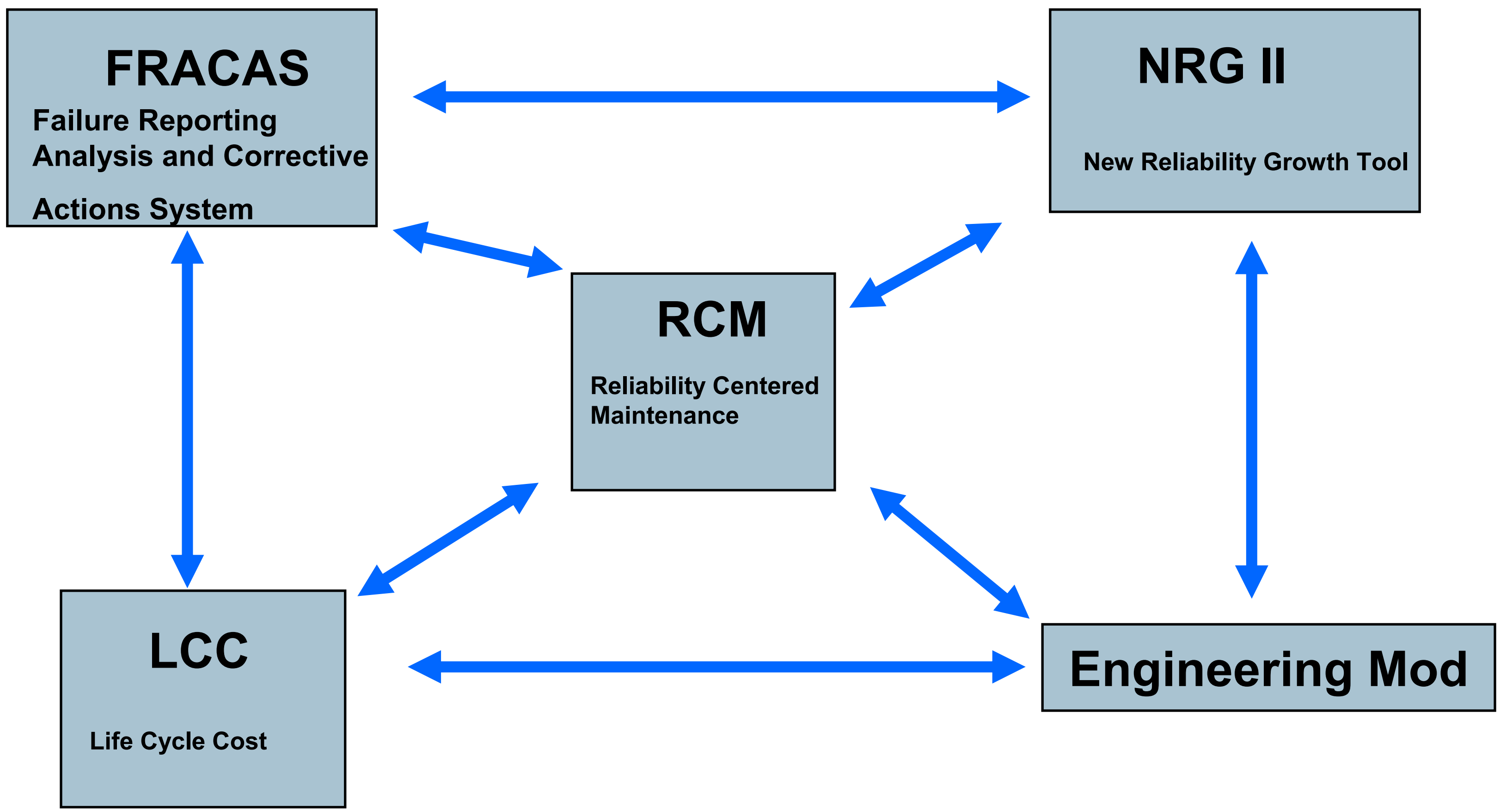
			Reliability performance		
			>= target	below 0 to -15%	below -15%
		Zone	1	2	3
LCC	Less 5%	1	1	2	3
	5 to 15%	2	2	4	6
	Above 15%	3	3	6	9

Priority weight

Safety failures have the highest priority

BOMBARDIER

Interactions between basic elements of reliability process



BOMBARDIER

Summary of NRG II Benefits

- Promotes a proactive approach to maturing product reliability
- Establishes corrective action priority based on comparisons of measured LCC and reliability values to target values
- Highlights to senior management reliability progress of all subsystems
- Reduces cost of Product Introduction
- Assists in modeling LCC
- Assists in performing trade-off analysis between EIS calendar date and expected EIS reliability
- Helps in optimizing maintenance program
- Applies to new product development or in-service improvements

Fosters idea that reliability growth is a responsibility we all share to achieve customer satisfaction

T&E for Verifying Technology Development and Maturation

Chris DiPetto

Deputy Director,

Developmental Test & Evaluation

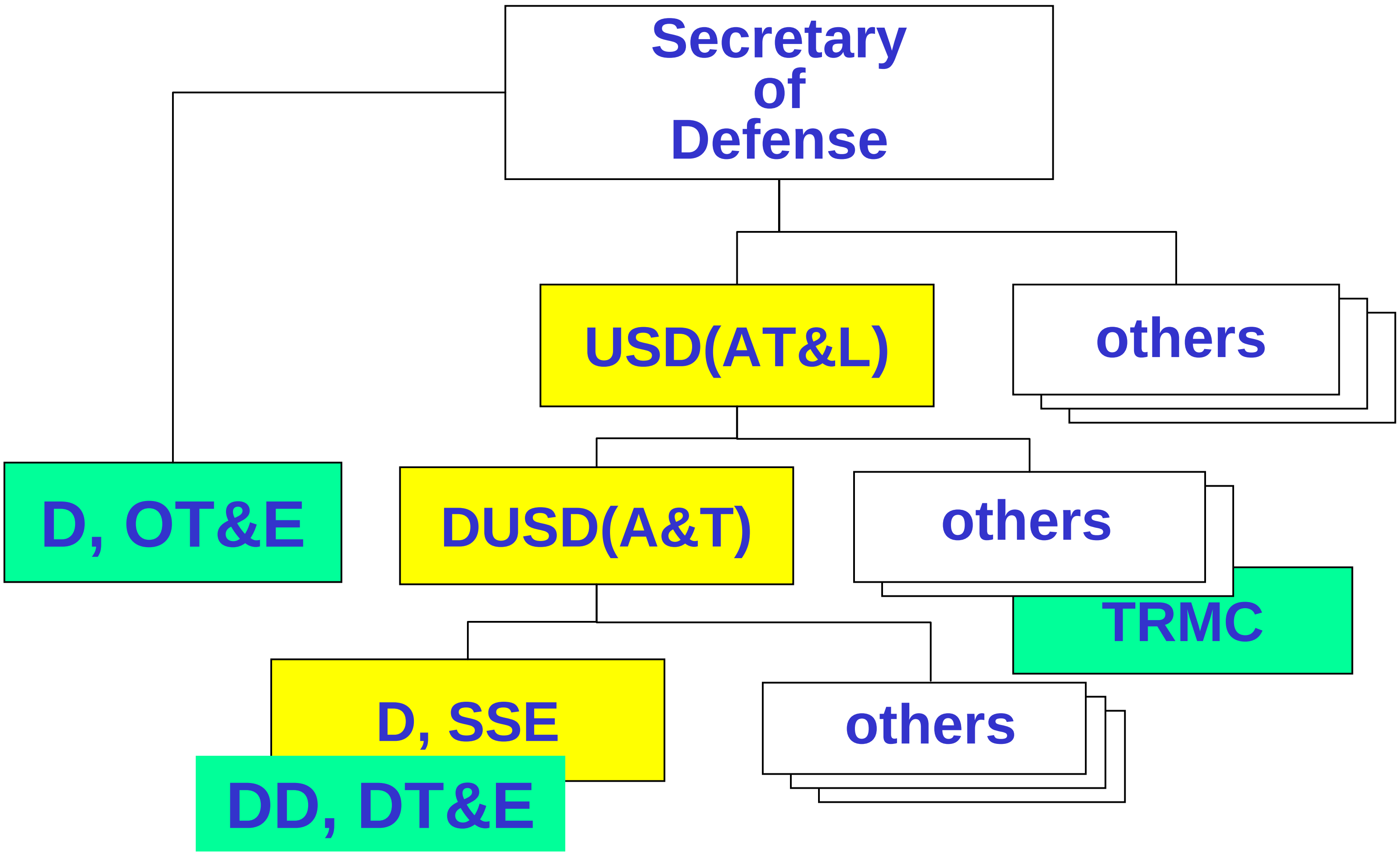
OUSD(AT&L)/Systems & Software Engineering

March 13, 2007

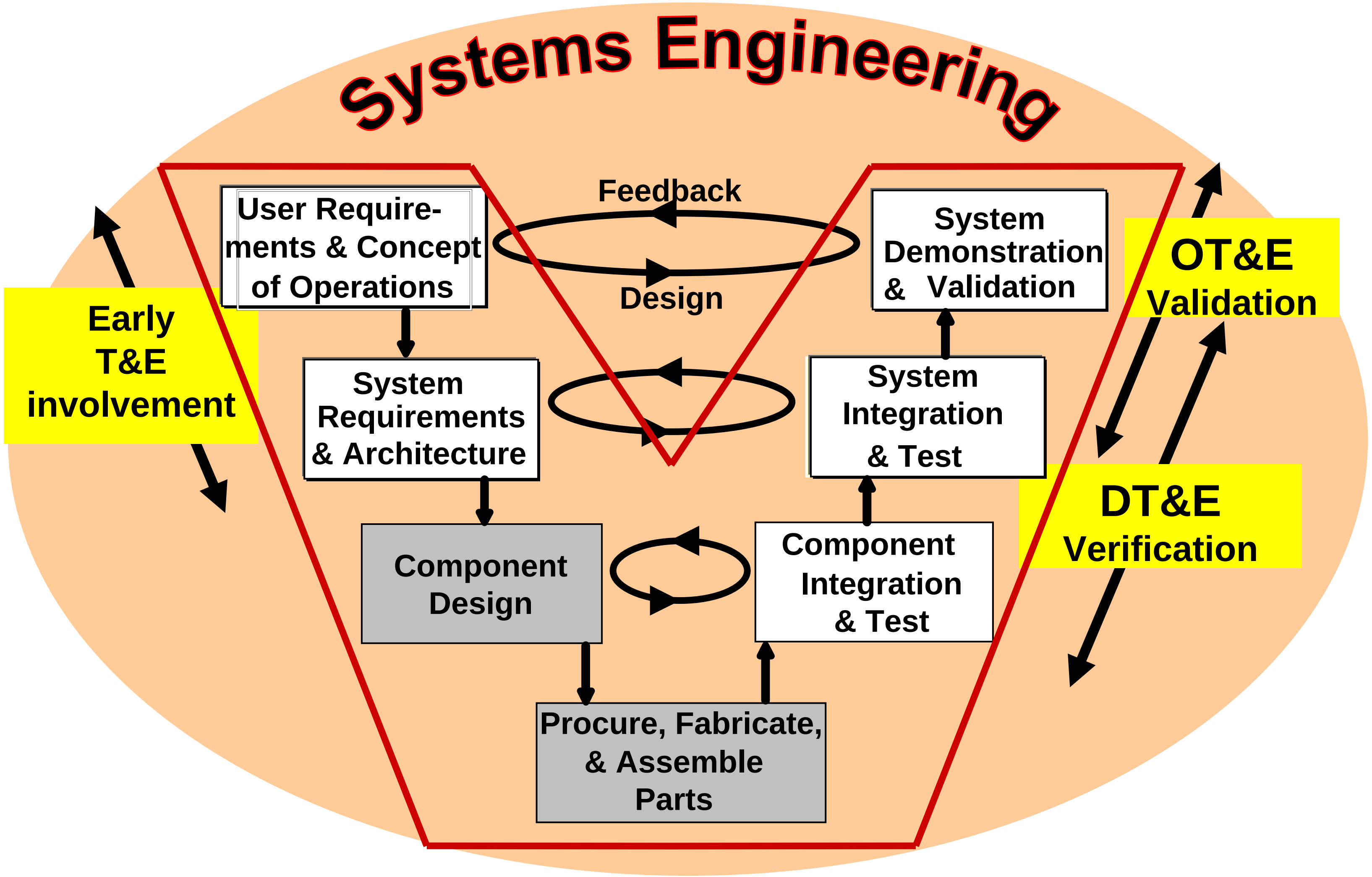
Outline

- Intro to OSD DT&E
- DT&E Priorities
- DT&E Technology Maturity Initiative
- Plan of Action

Where am I in OSD?



T&E Supports Systems Engineering



What's My Role?

Primary

- DT&E Policy & Guidance
- T&E Workforce Education

Secondary

- Acquisition M&S
- Systems Energy Policy
- DoD Acquisition System Safety

A New Vector for DT&E

My Priorities...

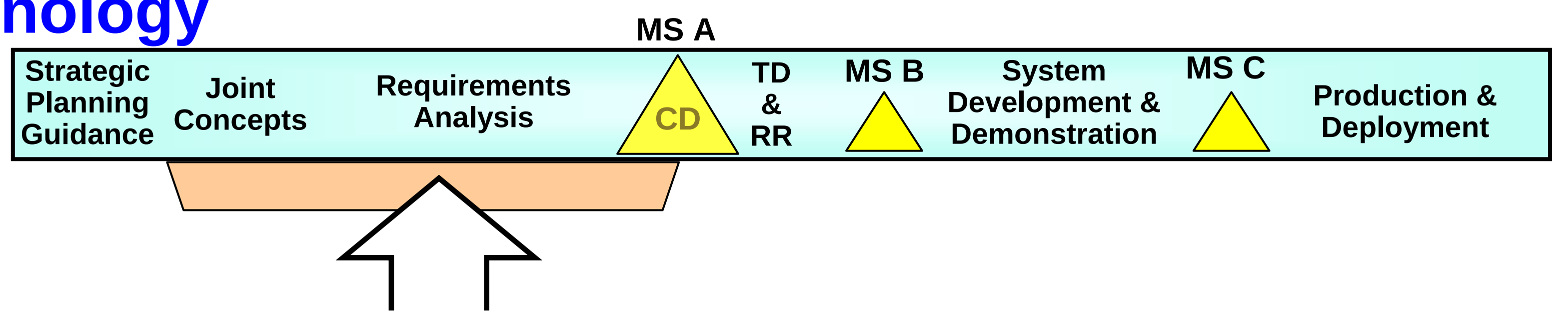
- **Support Faster Fielding of Improved Capabilities**
- **Reduce Risk of Immature Technology in Systems Development**
- Revitalize T&E Workforce Education
- Promote Joint T&E in Live-Virtual-Constructive Environments
- Provide Effective Acquisition Policy and Practices for DT&E

Support Faster Fielding of Improved Capabilities

- **2006 QDR: "...a more effective acquisition system and associated set of processes."**
- **Acquisition goal - cut time in half, from 10+ to 5- years**
  - **(1) reduce technical & programmatic risk, prior to program initiation**
  - **(2) change people's mind-set; focus on trading greater capability for earlier fielding**

New approach: evaluate cost, requirements, and technology alternatives - improved Concept Decision for MS A ("Big A")

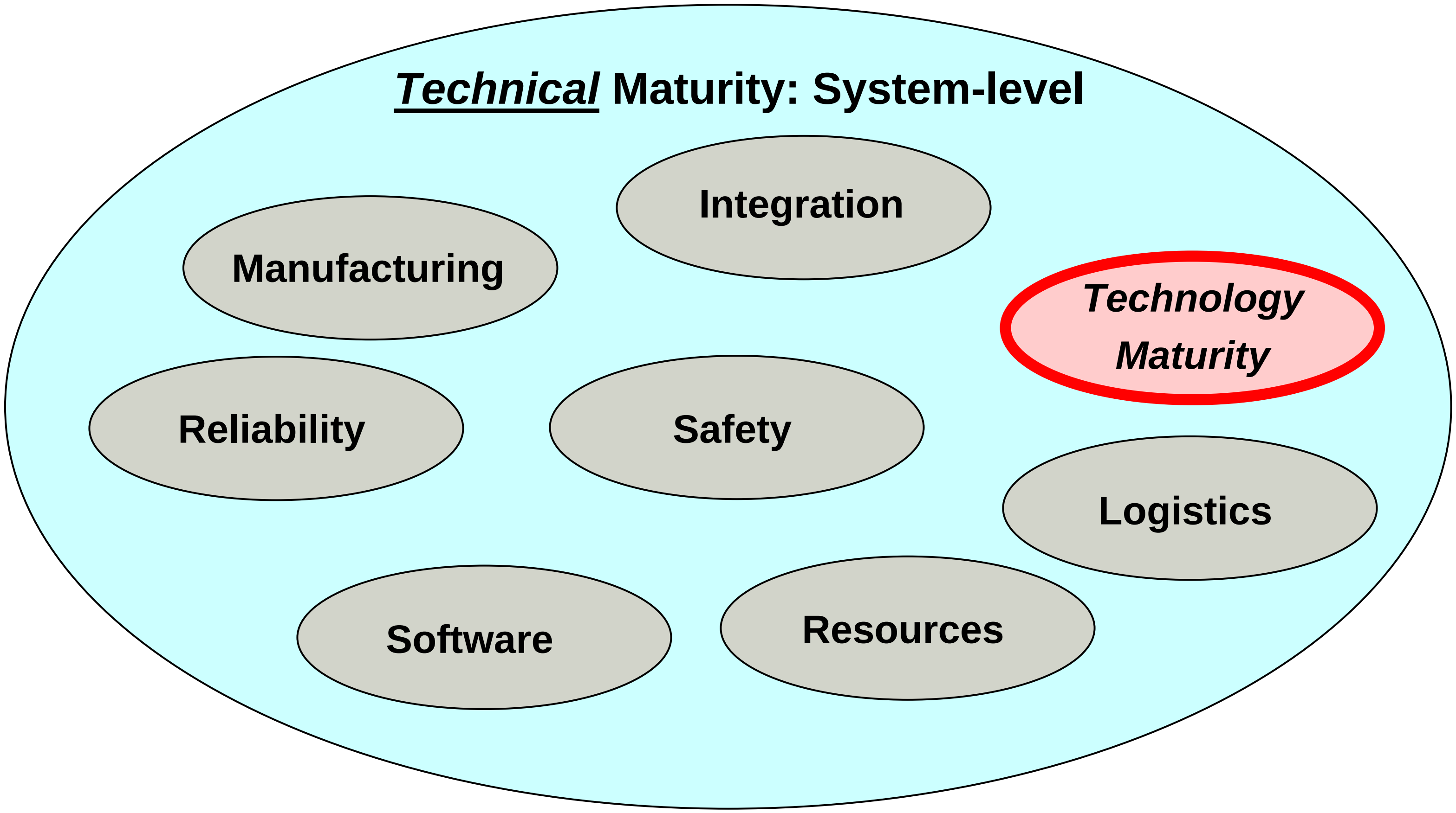
Result: start programs with firm requirements & mature technology



Role for DT&E

- Assure testable requirements in Big "A" Eval of Alt's / CD
- Include in request for proposal (RFP) T&E implications for System Development and Demonstration
- Fully integrate T&E strategy - CT, DT, OT
- Efficient test data philosophy: collect once, use often
- Not pass-fail; learn, define, understand system's capabilities and limitations...for fielding at predefined time
- Operational environment and operators in DT, soonest
- Mutually supporting plans:
  – Systems Engineering Plan
  – Test and Evaluation Master Plan
  – System development Statement-of-Work and RFP

Technology vs. Technical Maturity



Technology Maturity is a component- or subsystem-level issue

Reduce Risk of Immature Technology in Systems Development

- Studies find that immature technology is a primary source of cost and schedule risk
  - GAO -- DAPA
  - QDR -- SSE/AS Program Support Reviews

- "Programs that started development with **immature** technologies experienced an average acquisition unit cost increase of nearly **21 percent"** (GAO-05-301, March 2005)

- FY06, PL 109-163, Section 801 requires USD(AT&L) certification, before Milestone B, that *"the technology in the program has been demonstrated in a relevant environment"*
  - Above wording equates to Technology Readiness Level (TRL) 6

OSD Oversight Findings

- PM chose “a software architecture that depends upon COTS middleware that does not yet exist “
  - Although an alternative has been identified, no effort has been expended to pursue this solution
- “Technology maturity growth of critical Engineering Development Models lagging the plan”
  - PSR Recommendation: Initiate development of off-ramps to maximize operational performance
- “Technology Readiness Level (TRL) 6 of major subsystem at Milestone B is unlikely to be achieved; planned testing will not support accurate assessment of true maturity”
- “TRA conducted too late to influence decision process”

Major contributors to poor program performance

DT&E Technology Maturity Initiative

Purpose

- Add Technology Maturity focus into the Systems Engineering and DT&E processes to:
  - Reduce technical, cost, and schedule risk
  - Increase the rigor of SE
  - Plan for alternatives in the event of TM difficulty
  - Verify TRLs during DT&E
  - Updates will complement proposed Risk-Based Source Selection, Time-Defined Acquisition, and Concept Decision (CD) processes

Scope

- Leverage existing acquisition review structure
- Use existing DDR&E Technology Readiness Assessment (TRA) methodology

Technology Maturity Across System Lifecycle (as-is)

Technical Review	Decision	TRL (min)	
Initial Technical Review	CD	1*	
Alternative System Review	MS A	4*	
System Requirements Review	MS B	6	← Statute, per Sec 801
Systems Verification Review/ Production Readiness Review	MS C	7*	

* Guidance, not statute

Technology Maturity should be tracked between Milestones in Technical Reviews

Time-Certain Acquisition *Demands* Higher Technology Maturity

Technical Review Opportunities	Decision	TRL (min)	
Evaluation of Alternatives	EOA	4-5*	Compressed/ Merged
Alternative System Review (ASR)	CD	4-5*	
Systems Requirements Review	MS B	6 ←	Statute, per Sec 801
Systems Verification Review/ Production Readiness Review	MS C	7*	

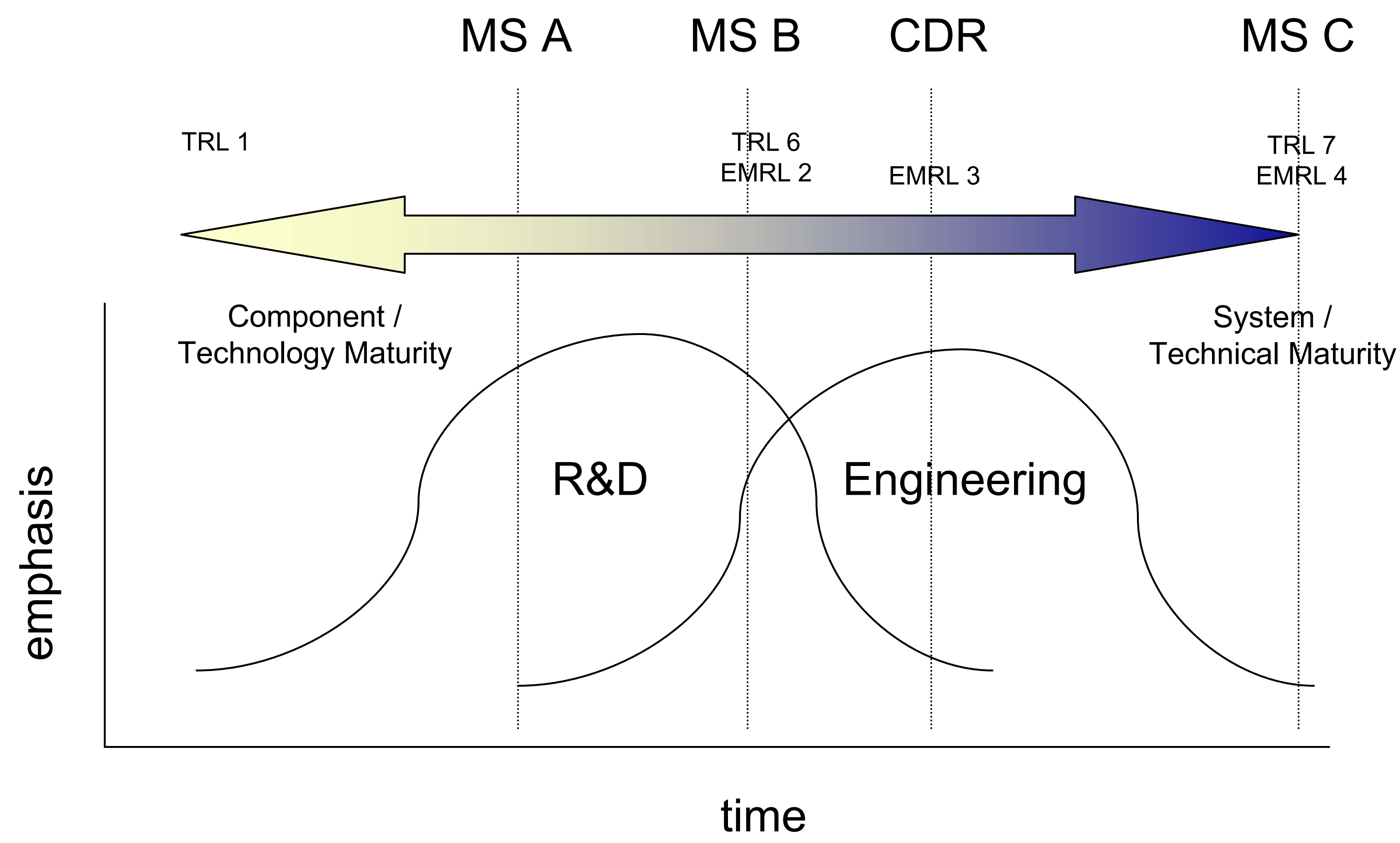
* Guidance, not statute

Plan of Action

- Changes in next update to Defense Acquisition Guidebook
  - SE and T&E Chapters
- Incorporate TM in recommended formats of
  - SEP, TES, TEMP
- Increase TM emphasis in OSD Oversight
  - PSRs, AOTRs
- Add emphasis on TM to DAU SE and T&E curriculum
  - CLM on TM planning
- Publicize renewed TM emphasis to DoD, Service, and Industry organizations

Back-up

Transition of Emphasis



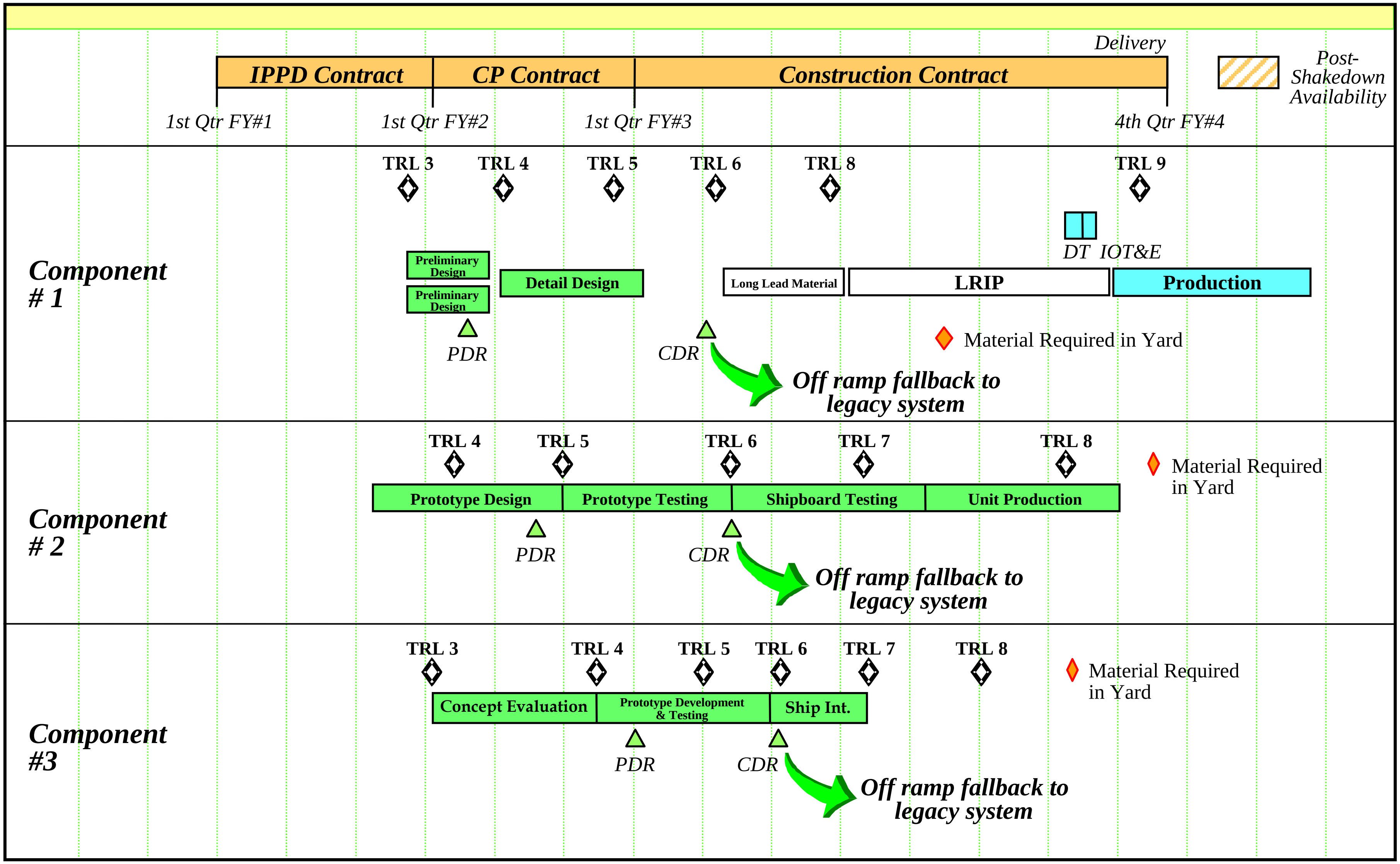
Hardware TRL Definitions

Decision:

Decision		
CD*	1.	Basic principles observed and reported
	2.	Technology concept and/or application formulated
	3.	Analytical and experimental critical function and/or characteristic proof of concept
MS A*	4.	Component and/or breadboard validation in a laboratory environment
	5.	Component and/or breadboard validation in a relevant environment
MS B	6.	System/subsystem model or prototype demonstration in a relevant environment
MS C*	7.	System prototype demonstration in an operational environment
	8.	Actual system completed and qualified through test and demonstration
	9.	Actual system proven through successful mission operations

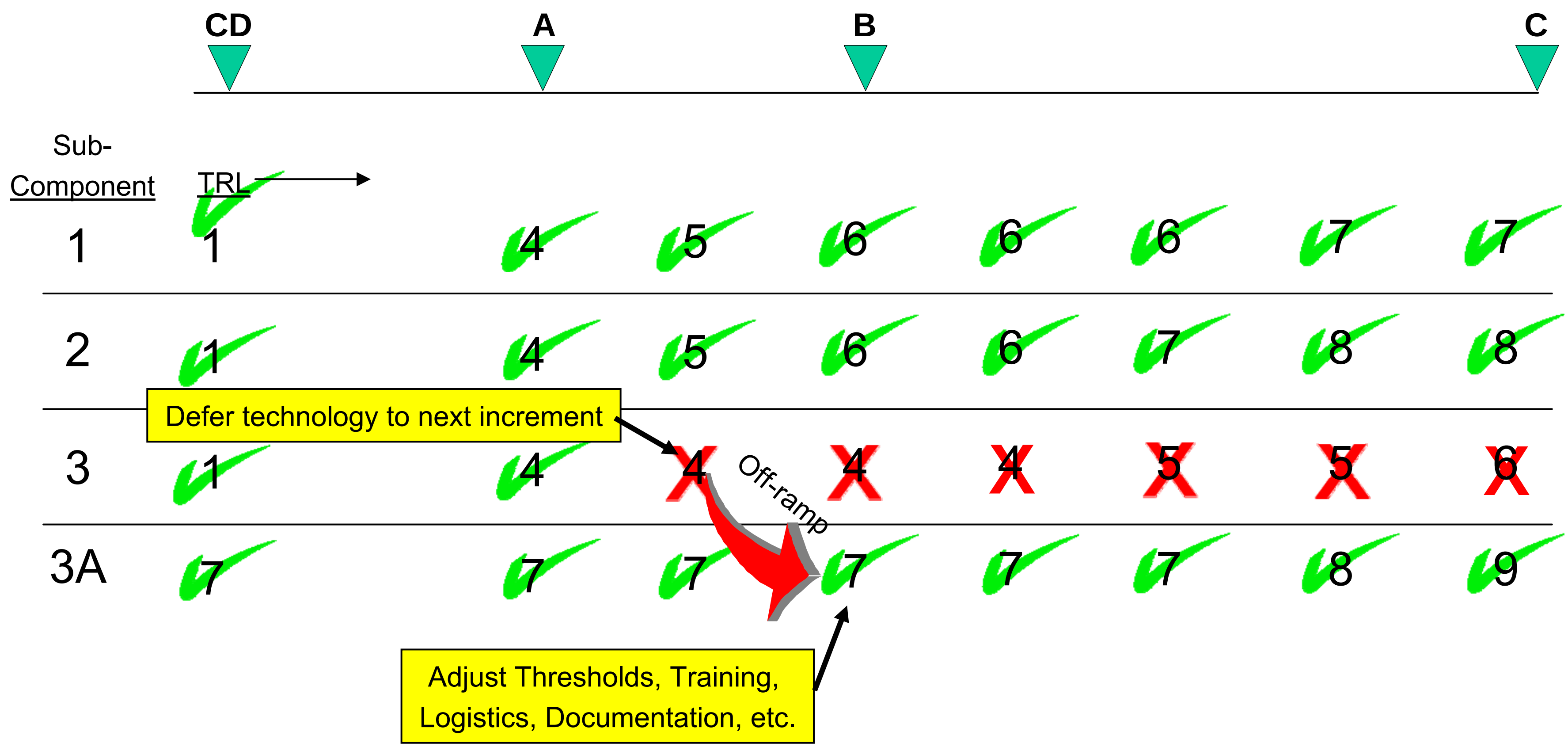
* Guidance, not statute

Critical Technology "Off-Ramps"



TRL Impact on SE

Example of Pre-planned “Off-ramp”



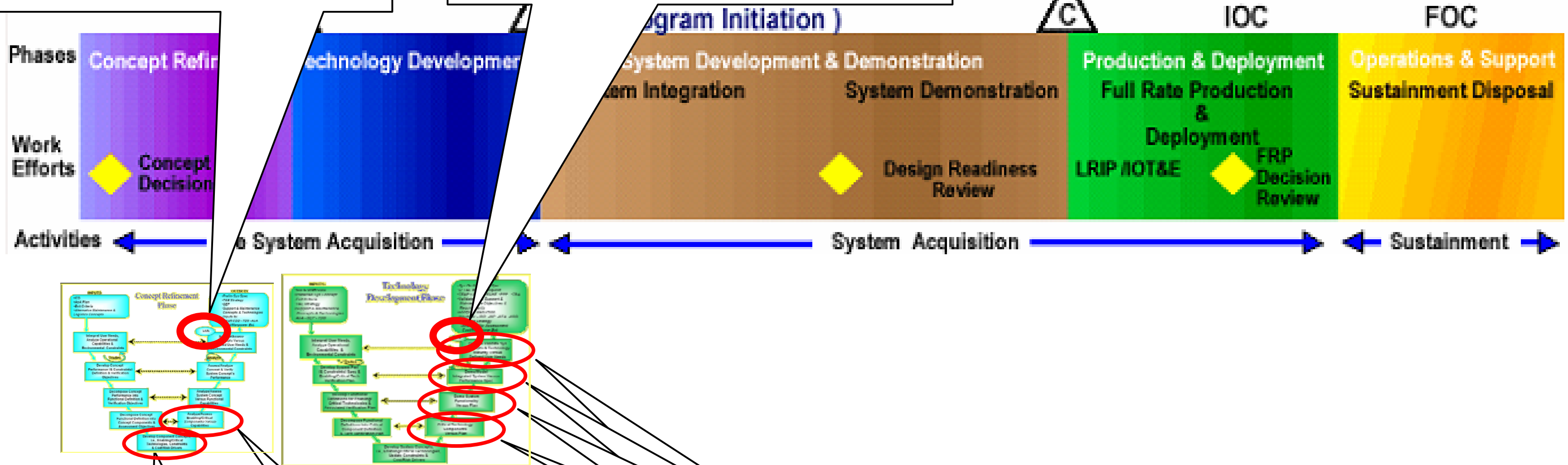
Sub-component “3” does not mature at required rate. Off-ramp to mature sub-component “3A” is chosen before MS B.

TM Activities in SE Process

ASR:
-ID immature critical technologies w/ maturation plans
-ID mature alternatives w/ performance/other trades
-TDS

SRR:
-All critical technologies (or alternatives) ≥ TRL-6
-Acceptable performance, balanced vs capability need, cost, schedule, etc.
-Support MDA cert at MS B

Technical Review Exit Criteria



-ID immature critical technologies
-ID mature alternatives

-Assess performance w/ critical technologies
-Assess performance w/ mature alternatives

-Demo/Assess performance
-Verify TRLs
-Track TM progress vs plan
-Take Off-ramp (if req'd)

DT&E Role, in Preps for Technical Reviews

NDIA 23RD ANNUAL NATIONAL T&E CONFERENCE

Hilton Head Island, SC
14 March 2007

Joseph W. Dyer

President,

Government & Industrial Division

jdyer@irobot.com

Forward Looking Statements

- Certain statements made in this presentation that are not based on historical information are forward-looking statements which are made pursuant to the safe harbor provisions of the Private Securities Litigation Reform Act of 1995.

- These statements are neither promises nor guarantees, but are subject to a variety of risks and uncertainties, many of which are beyond our control, which could cause actual results to differ materially from those contemplated in these forward-looking statements.

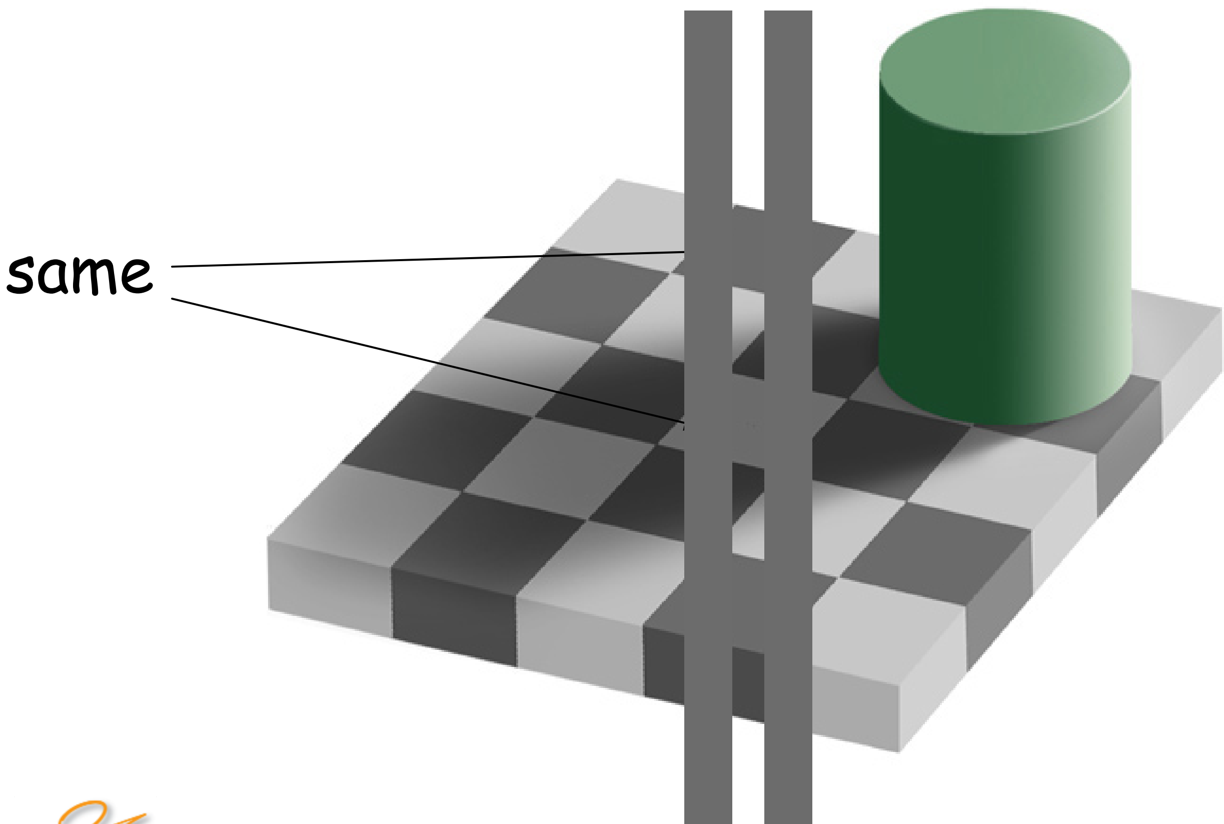
- Existing and prospective investors are cautioned not to place undue reliance on these forward-looking statements, which speak only as of the date hereof. iRobot Corporation undertakes no obligation to update or revise the information contained in this presentation, whether as a result of new information, future events or circumstances or otherwise.

- For additional disclosure regarding these and other risks faced by iRobot Corporation, see the disclosure contained in our public filings with the Securities and Exchange Commission.

PREDICTING THE FUTURE CAN BE DIFFICULT

I, ROBOT THE MOVIE

The Checkerboard "Illusion"



Here, the human visual system infers the color of the checks in the world, not the gray value in the image.

The "illusion" reflects the successful design of the visual system, not a quirky failure.

Disruptive Technologies Timeline

Massive disturbances occur with the introduction of disruptive technology.
Life before and after a disruptive technology is fundamentally different.

Disruptive Technologies Timeline

Computers 1978 = Robots 2002

- Locked away from public
  - too dangerous for computers
- Used inside large companies
- Operational use in military
- First few “home” computers
  - in the form of games
- Computer hacking clubs
- How-to-build-your-own books
- Undergraduate majors appearing
- First mass market “serious” home computer attempts

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iRobot®
PackBot®

iRobot®
Scooba

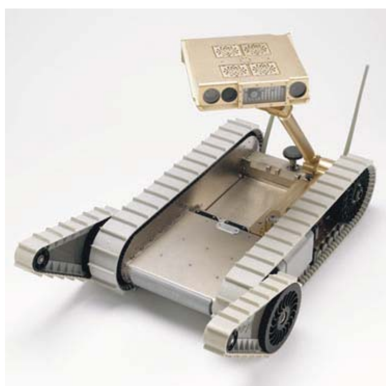
iRobot®
Roomba

iRobot What We Do

PackBot w/ Recon kit, Afghanistan, 2003

PackBot w/EOD kit, Iraq, 2006

PackBot w/Recon kit



PackBot w/Advanced Recon kit

PackBot w/EOD kit

iRobot SUGV for FCS Exp. 1.1, WSMR 2007

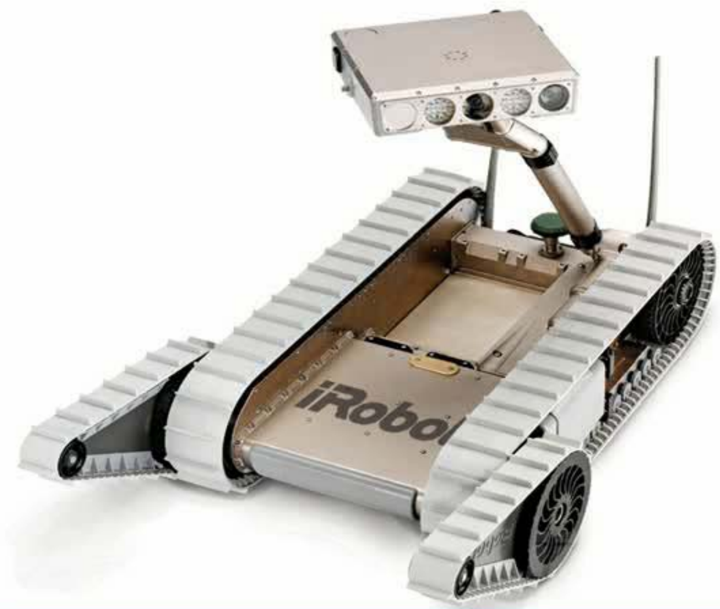
iRobot Warrior X700

iRobot is integral to the 21st Century Military

- 81 robots per combat brigade team
- 3,600 robots
- Spares, upgrades, training, service, and support throughout the lifecycle
- A 30+ year business opportunity

- Fully Integrated into:
  - Logistical Supply Chain
  - Communications Network
  - Training Programs
  - Doctrine Development Programs

ROBOTS IN FUTURE URBAN ENVIRONMENTS



iRobot

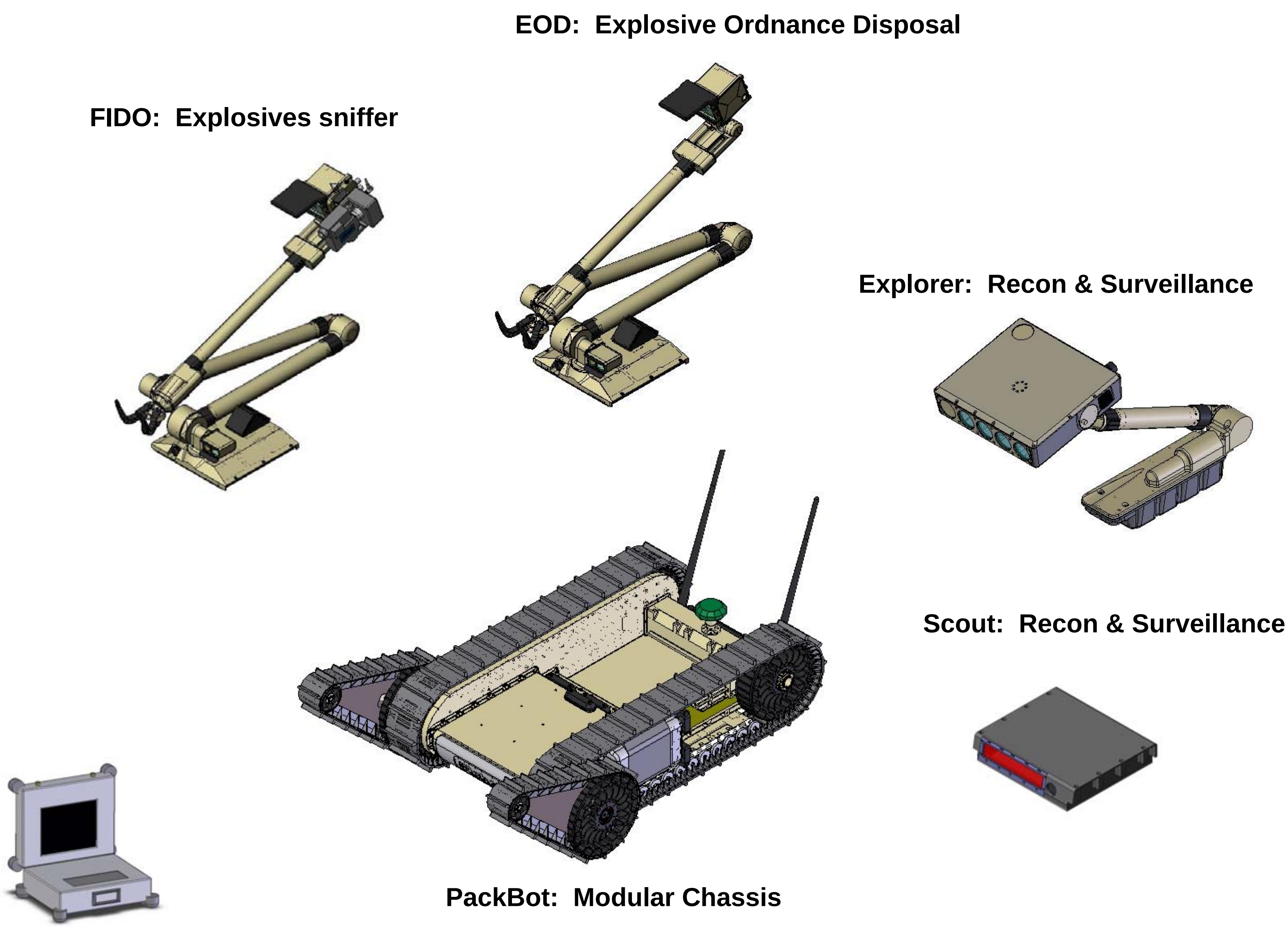
Air Assault Expeditionary Force (AAEF) Experiment, Ft. Benning, GA 2005 & 2006

- **2005**
  - **First question: "Captain, of all the new technologies and capabilities you've used during this AAEF experiment, which one single piece would you deploy today?"**
  - **Answer: "<u>Sir, the Packbot ('SUGV'.)"</u>**
- **2006**
  - **First question: "Captain - what three systems employed at this experiment would you want to take to war?"**
  - **"Sir, the Raven & Buster uav's and a ugv - sir, the Packbot ('SUGV')."**
  - **"Why did you single out those three?"**
  - **"Sir, i wanted sa (situational awareness) - from the air and from the ground. The packbot was RELIABLE and light enough (to carry.) the Raven was also reliable. I said two uav's because I always wanted one."**

iROBOT WARRIOR

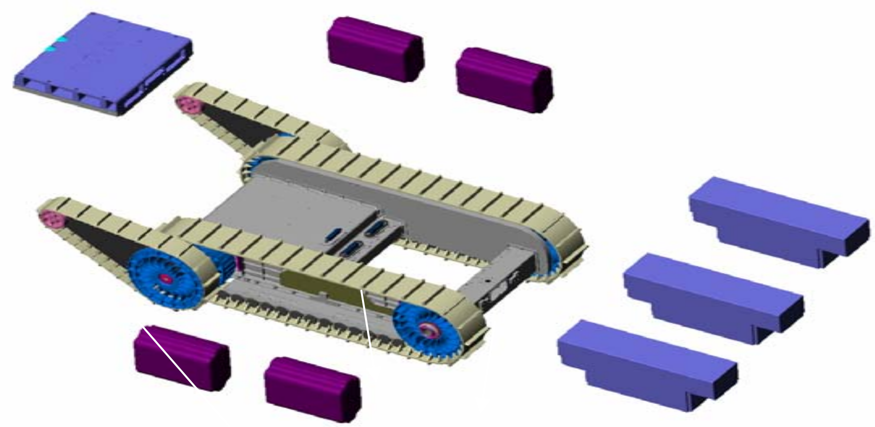
iRobot – John Deere Robotic Gator

PackBot: Digital Modular Architecture



iRobot PackBot – A Digital Machine…

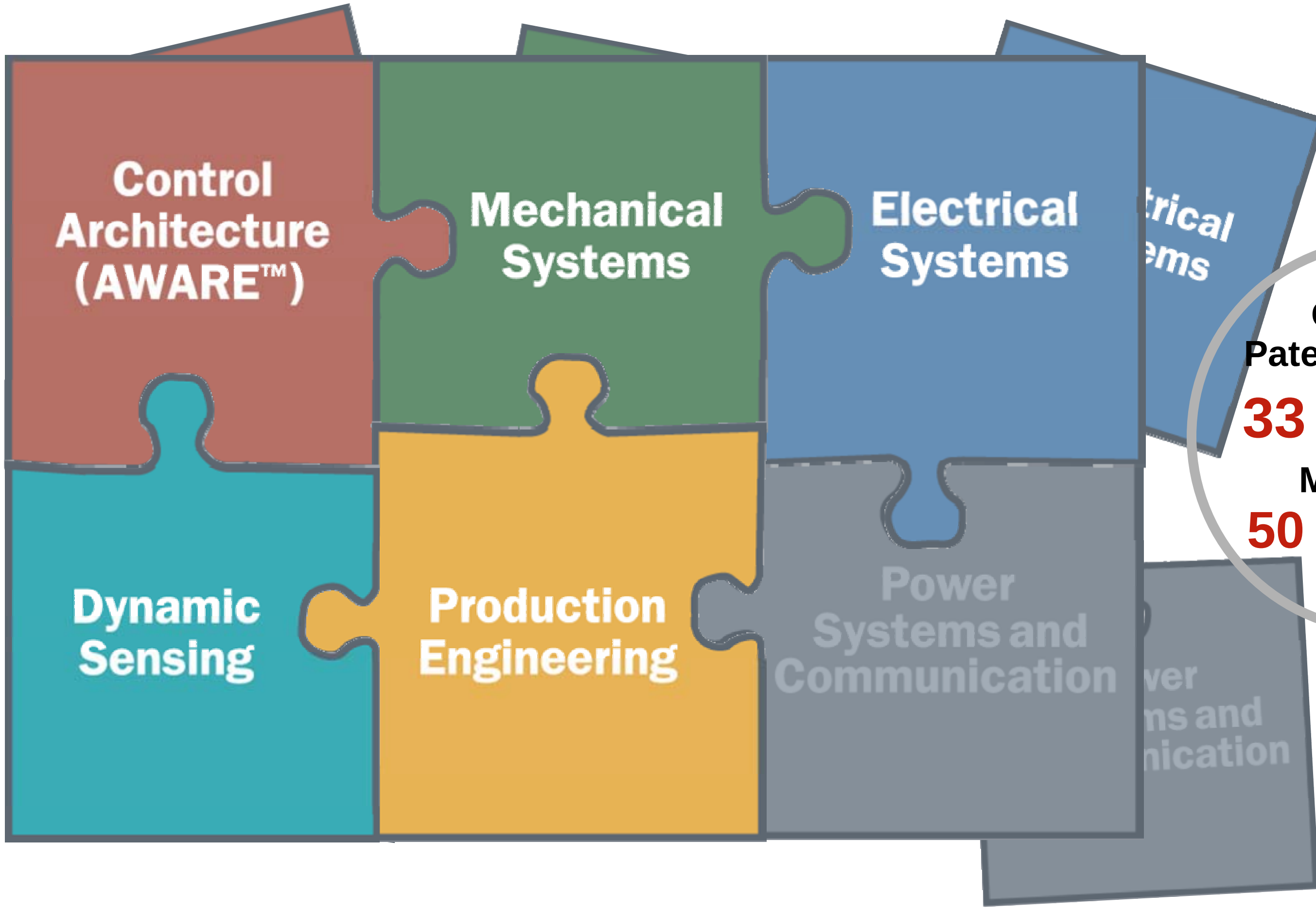
- **Modular Payload Architecture**
  - 1 Front Payload
  - 4 Side Payloads
  - 3 Rear Payloads



- **Signals**
  - Ethernet
  - USB
  - Motion Control
  - Power
  - 2 Video Channels

Digital Architecture & Systems Integration

Technology Core Competencies



Growing Patent Portfolio:

33 Patents

More than

50 Pending

Nomadics FIDO + iRobot PackBot

Explosives Detector

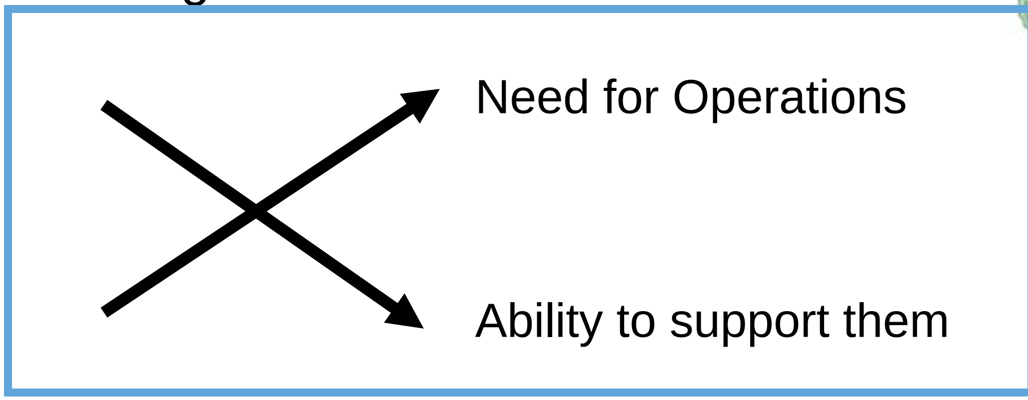
SAFETY FROM STANDOFF:
PackBot carries the sensor to the vehicles, so Soldiers aren't exposed.

THE DETECTION OPPORTUNITY:
Explosives leave invisible traces of vapors which FIDO can sniff and detect.

"FIDO was able to detect explosives 80 feet away. This allowed separation of the Soldiers and dog from the bomb, thus saving lives. . . ."

Military Engagement – The Word is a More Dangerous Place

- High tempo military operations and a dramatically lower tolerance for causalities and POW’s.
- U.S. volunteer force resources are being stretched

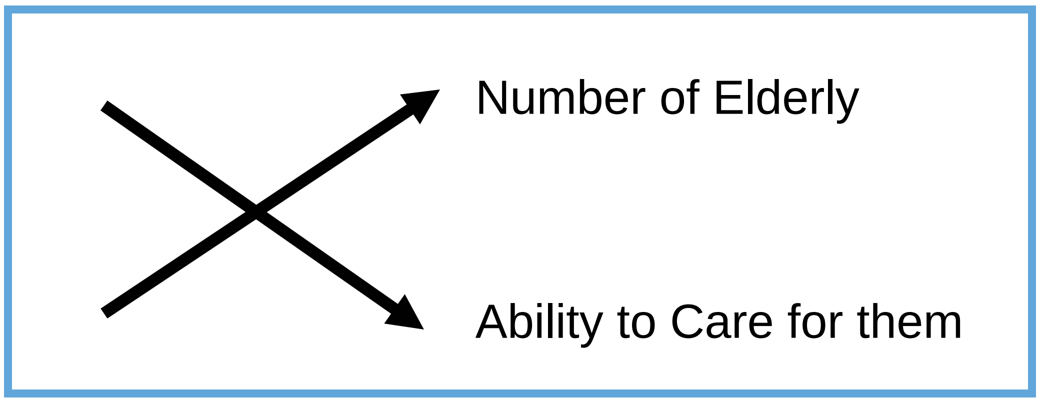


- **The US cannot afford to spend our way out of this problem using current technology and doctrine**

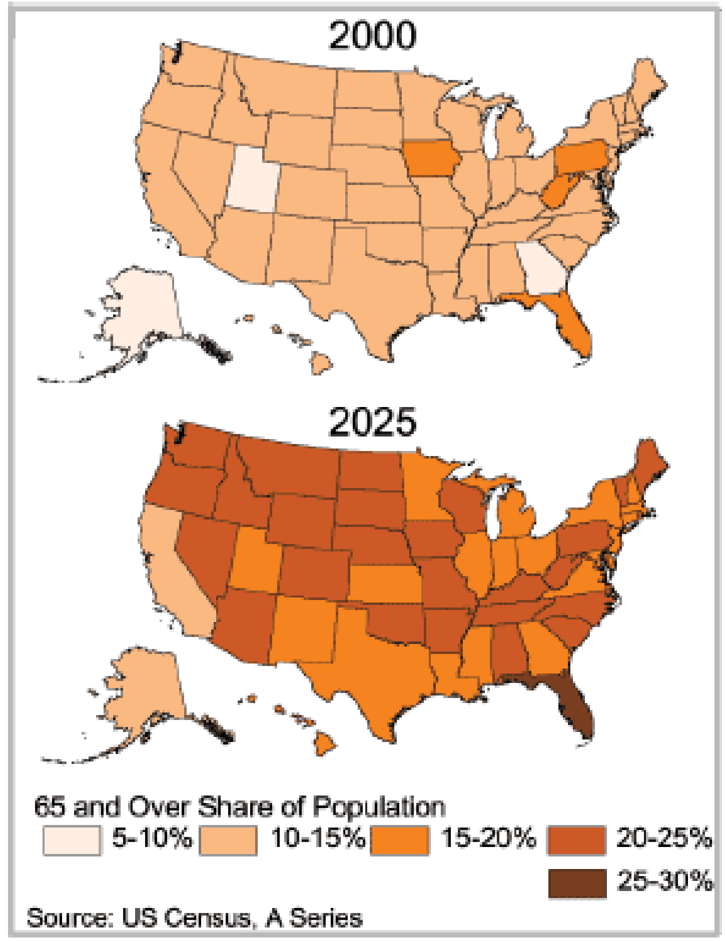
We have over 350,000 SOLDIERS overseas in 120 countries

Long Term Driver

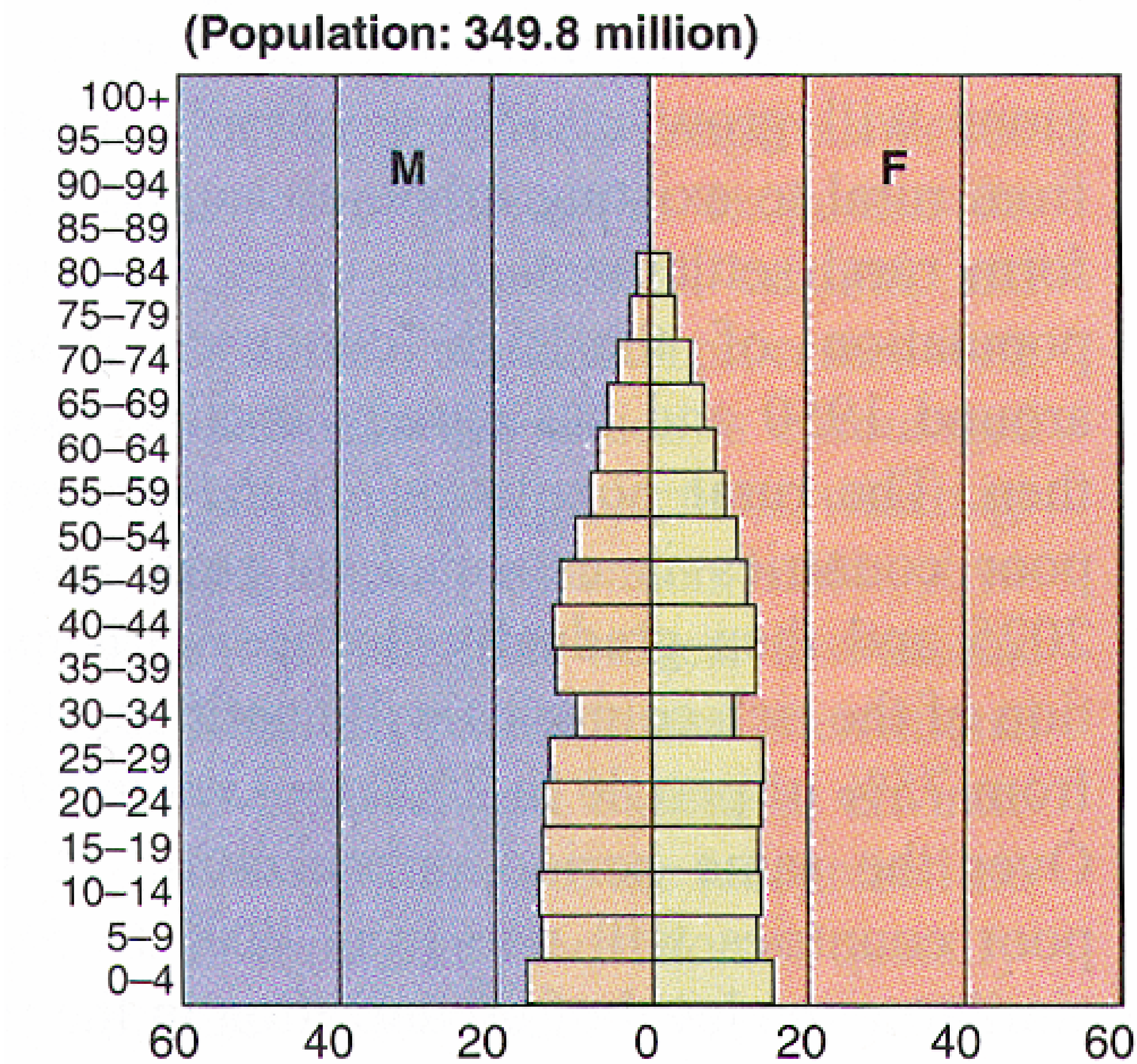
- Our current ability to care for the elderly is barely adequate and in decline
- A massive increase in the number of elderly people is imminent



- **We cannot simply spend our way to a solution.**

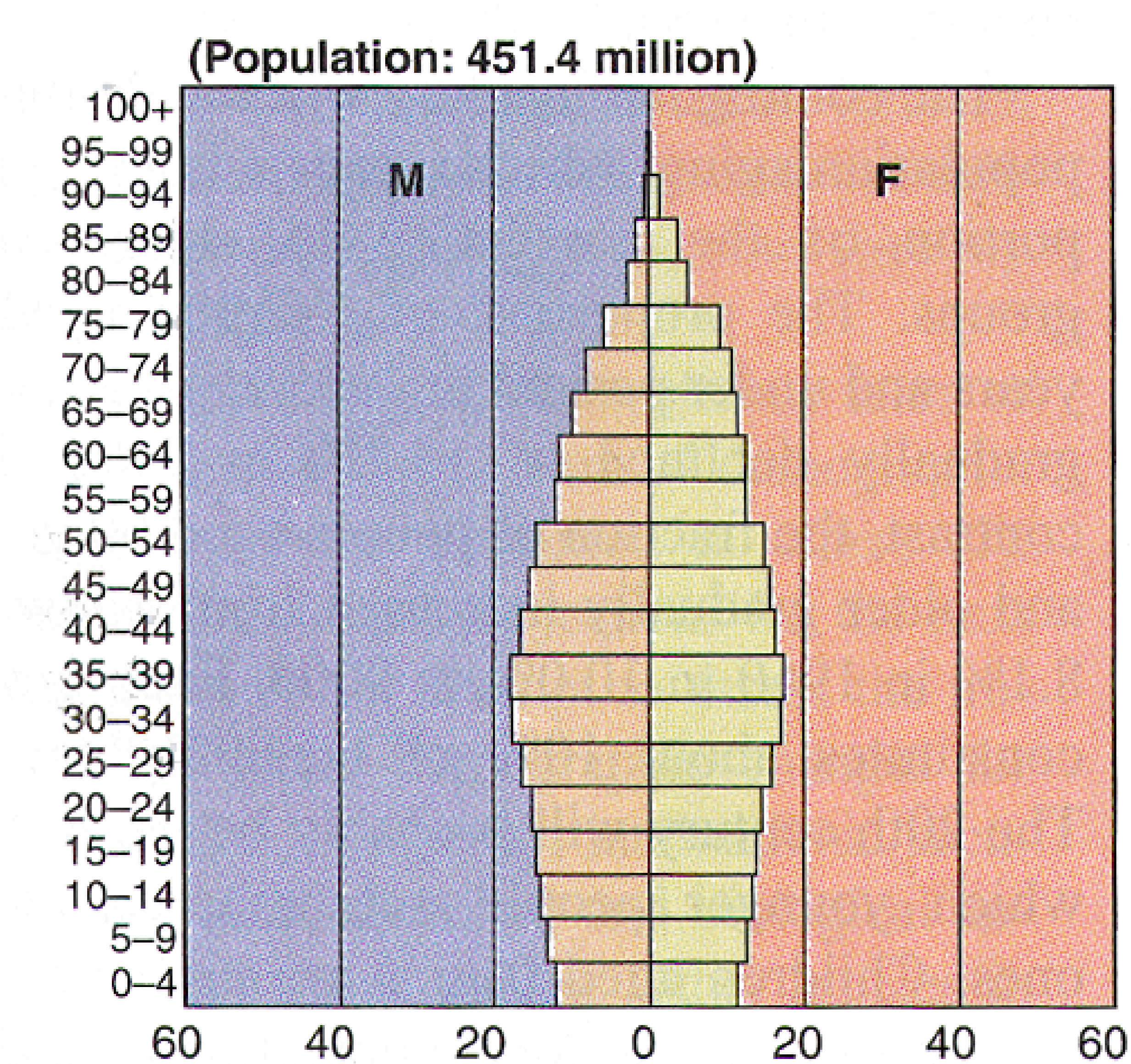


Europe - 1950



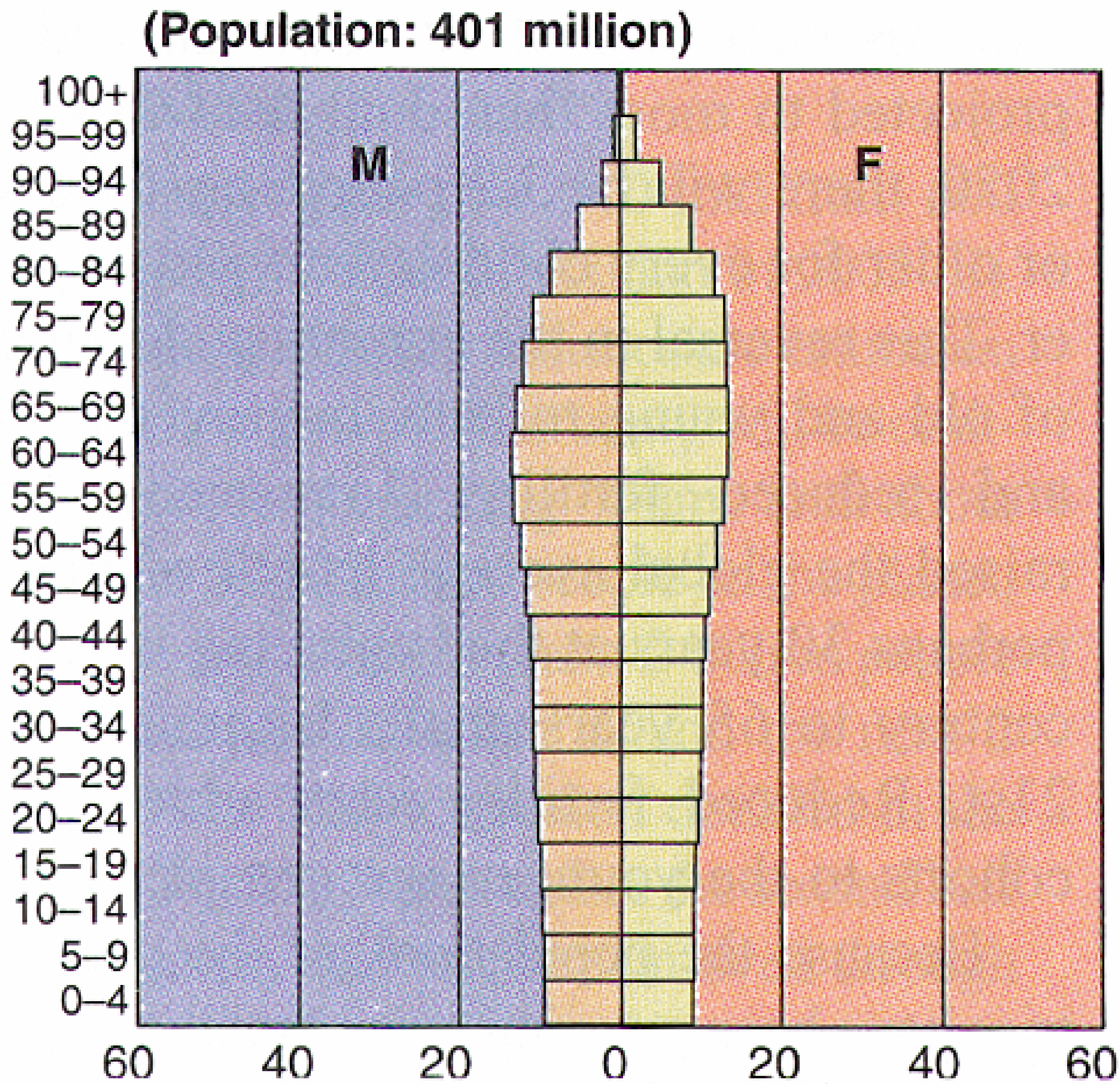
(Population: 349.8 million)
100+
95–99
90–94
85–89
80–84
75–79
70–74
65–69
60–64
55–59
50–54
45–49
40–44
35–39
30–34
25–29
20–24
15–19
10–14
5–9
0–4
M
F
60
40
20
0
20
40
60

Europe - 2000



(Population: 451.4 million)
100+
95–99
90–94
85–89
80–84
75–79
70–74
65–69
60–64
55–59
50–54
45–49
40–44
35–39
30–34
25–29
20–24
15–19
10–14
5–9
0–4
M
F
60 40 20 0 20 40 60

Europe - 2050


(Population: 401 million)
M
F
100+
95–99
90–94
85–89
80–84
75–79
70–74
65–69
60–64
55–59
50–54
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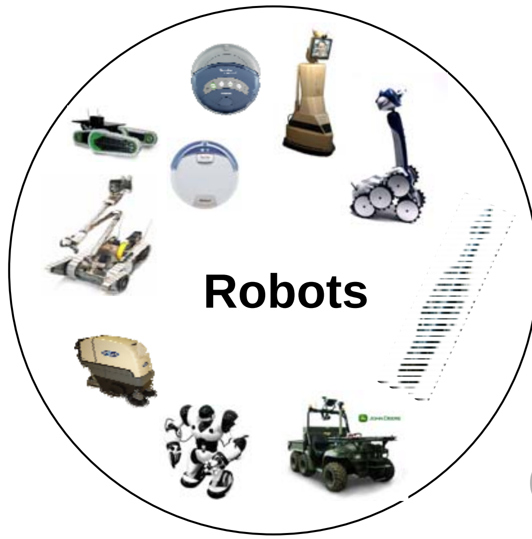
20
40
60

The Robot Industry



Home
- Vac
- Mop
- Mowing
- Security

Health
- Hospital
- Long term care
- Home care

Military
- UUV
- UGV
- UAV

Energy & Utility
- Mining
- Oil & Gas

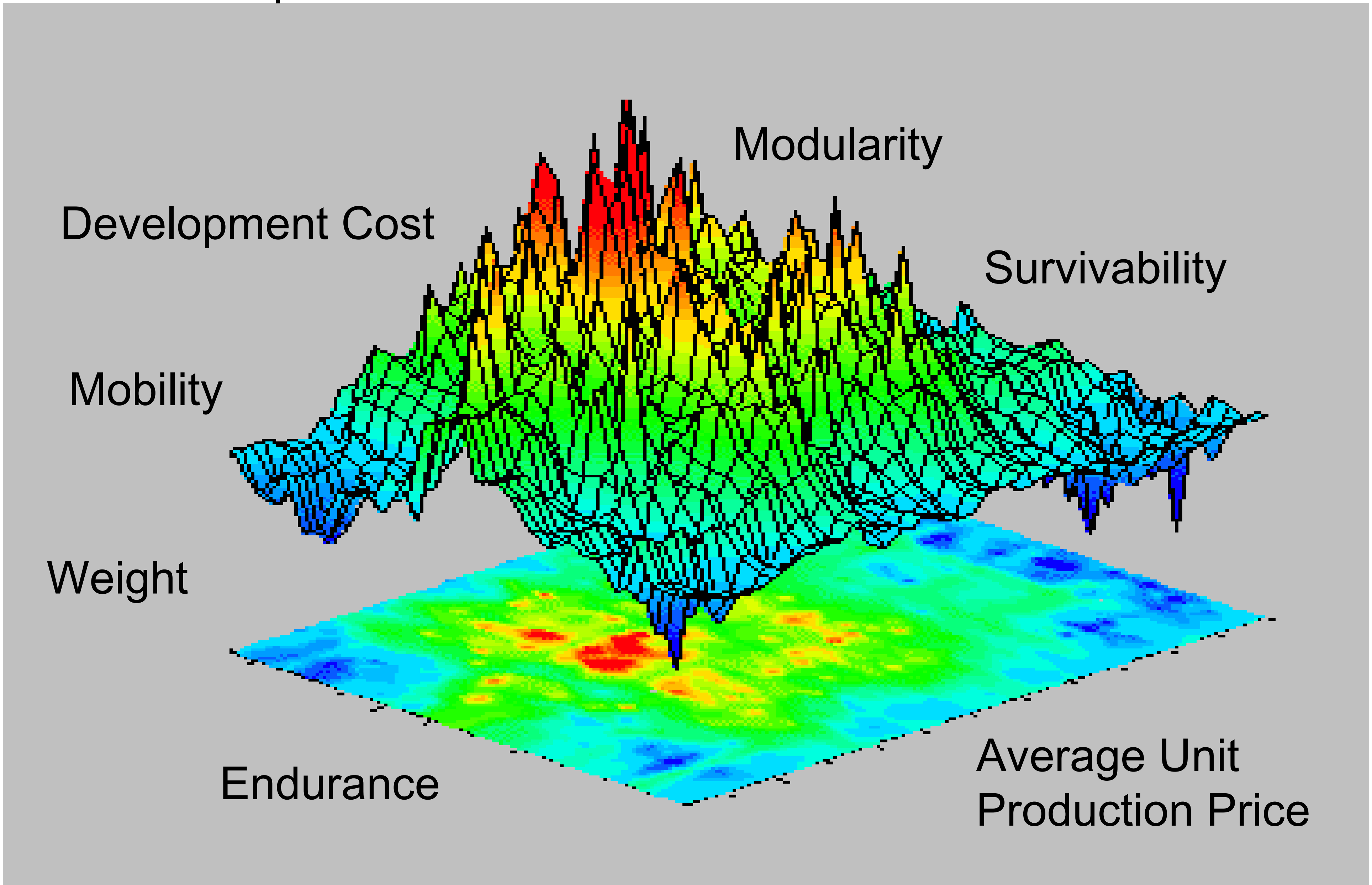
Industrial cleaning
- Wet
- Dry

Toys

Farming

Construction

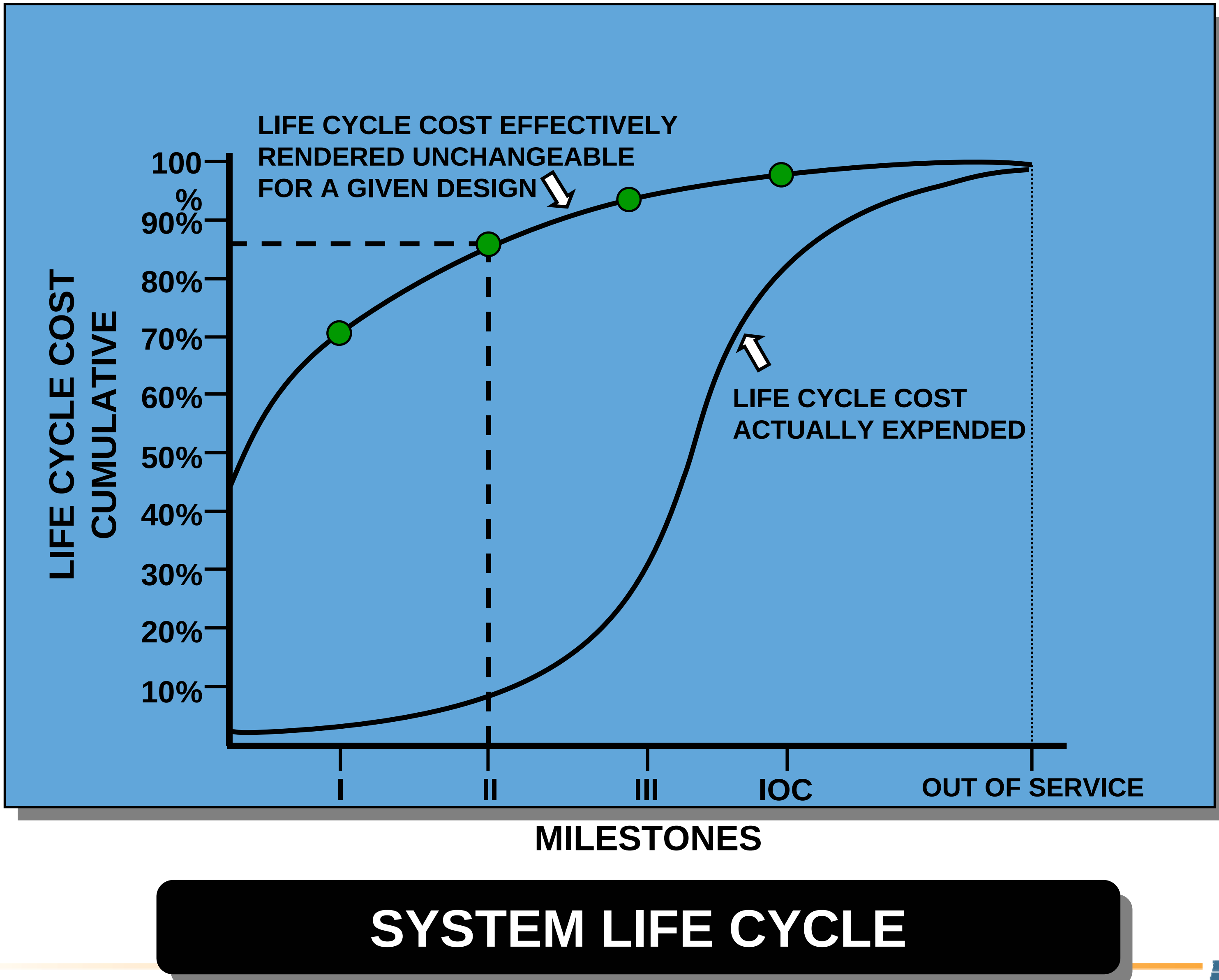
Trade Space


Modularity
Development Cost
Survivability
Mobility
Weight
Endurance
Average Unit
Production Price

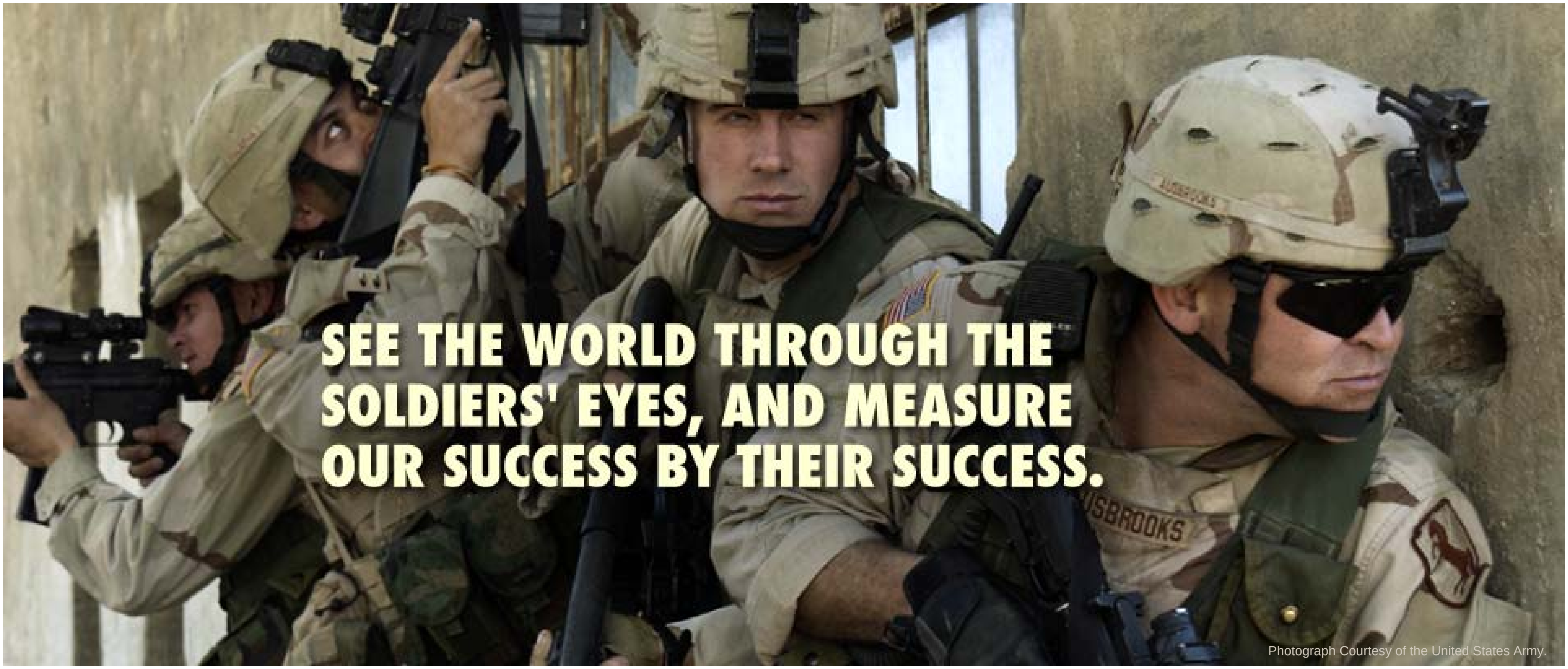
SOUTHWEST RESEARCH INSTITUTE

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Early Decisions Affect Life Cycle Cost



Soldiers will find more missions for robots than expected


SEE THE WORLD THROUGH THE SOLDIERS' EYES, AND MEASURE OUR SUCCESS BY THEIR SUCCESS.
USBROOKS
Photograph Courtesy of the United States Army.

Computers 1978 = Robots 2001

- Locked away from public
  - too dangerous for computers
- Used inside large companies
- Operational use in military
- First few “home” computers
  - in the form of games
- Computer hacking clubs
- How-to-build-your-own books
- Undergraduate majors appearing
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- First mass market “serious” home robot attempts

Big Application - Manufacturing

- currently: robot arms for “fixed automation”
- future: flexible low-cost manufacture
  - dexterous assembly/fabrication of small low cost products
  - currently we outsource this to low cost developing-world labor
  - what are the technical challenges?

Consequences

- Completely change the world's labor markets from the way they have developed over the last 50 years
  - change the need for low-cost labor migration
  - change the face of out sourcing
  - significantly impact the labor requirements for elder-care in societies with changing demographics
  - CHANGE THE WAY THE MILITARY OPERATES
- Potential to create an economic tsunami that rivals or surpasses the silicon valley experience

Deliver Great Product

Roomba SCHEDULER
VACUUMING ROBOT

iRobot

Make Money

Have Fun

Change the World

A Better Way

More than 500 PackBot® Military Robots delivered

"You have saved lives today!"

"When a robot dies you don't have to write a letter to its mother."

iRobot®

THANK YOU!

jdyer@irobot.com

Big Application - Manufacturing

- currently: robot arms for "fixed automation"
- future: flexible low-cost manufacture
  - dexterous assembly/fabrication of small low cost products
  - currently we outsource this to low cost developing-world labor
  - what are the technical challenges?

iRobot Today

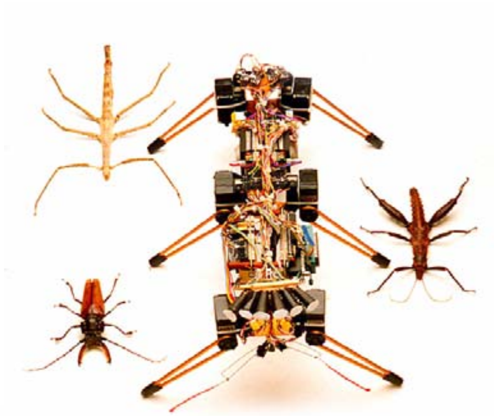
- 142 Million in 2005 Revenue
- 400 Employees*
- Offices in 3 US locations + Hong Kong and India

- Over the past 3 years, shipped over $.25 Billion of robots to a diverse set of customers

*includes consultants and temporary employees

Behavior-Based Robots

- **Fast connections between sensors and actuators**
- **Composable behaviors**
- **Multiple simultaneous goals with dynamic arbitration**
- **Dynamically variable degrees of autonomy**

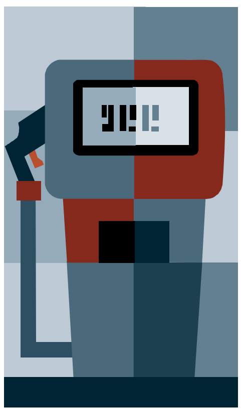


Creature-like control system

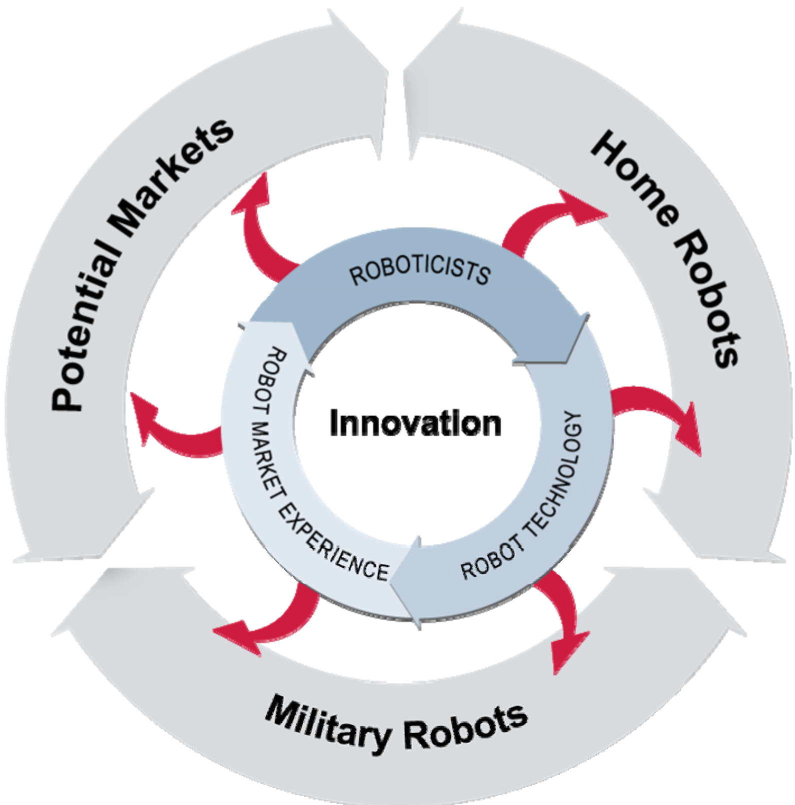
Our Innovation Engine

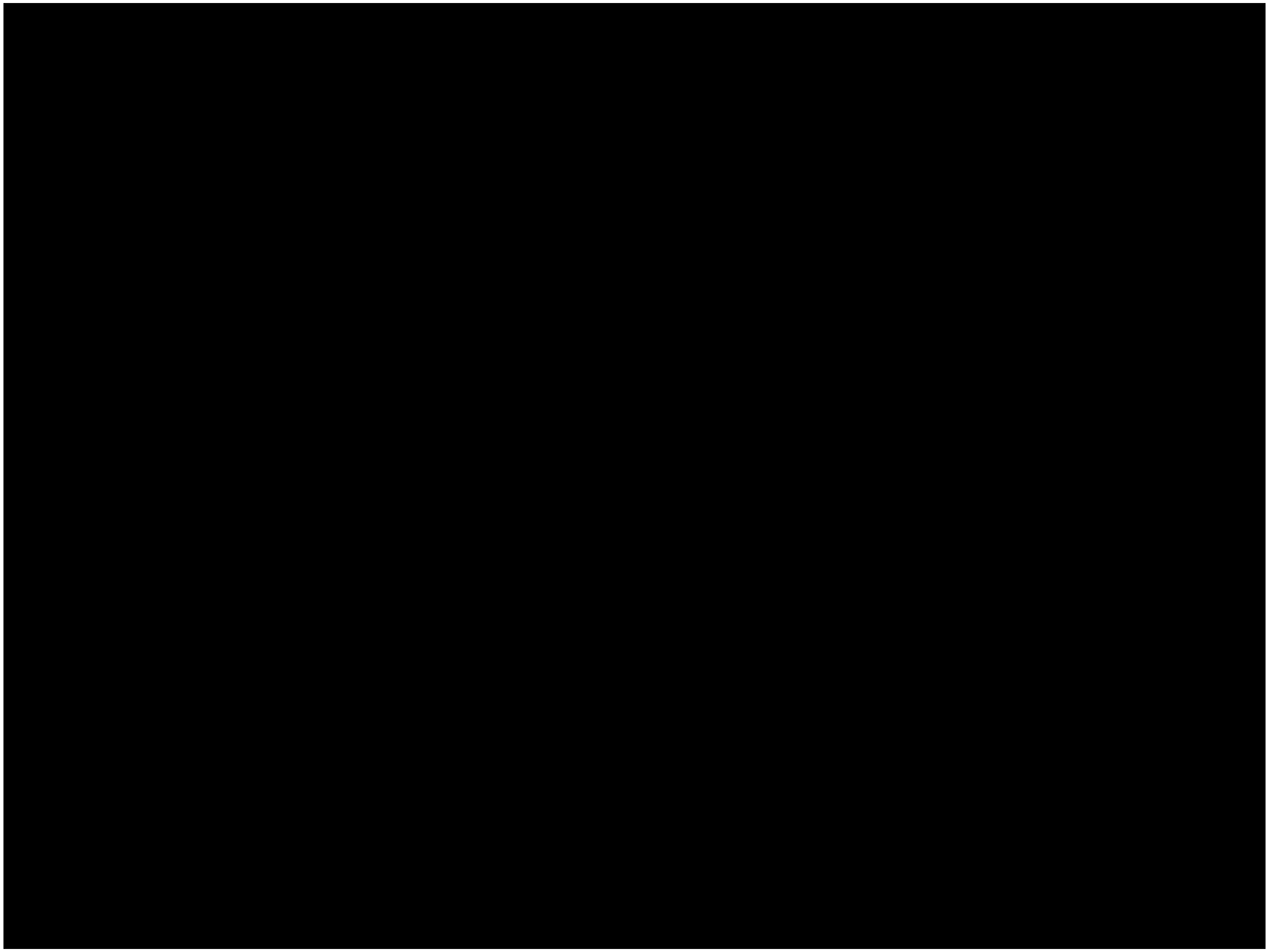
7%
IR&D
+
8%
Gov't
R&D

15%



Prior 4 Quarter Investments
as a % of Revenue

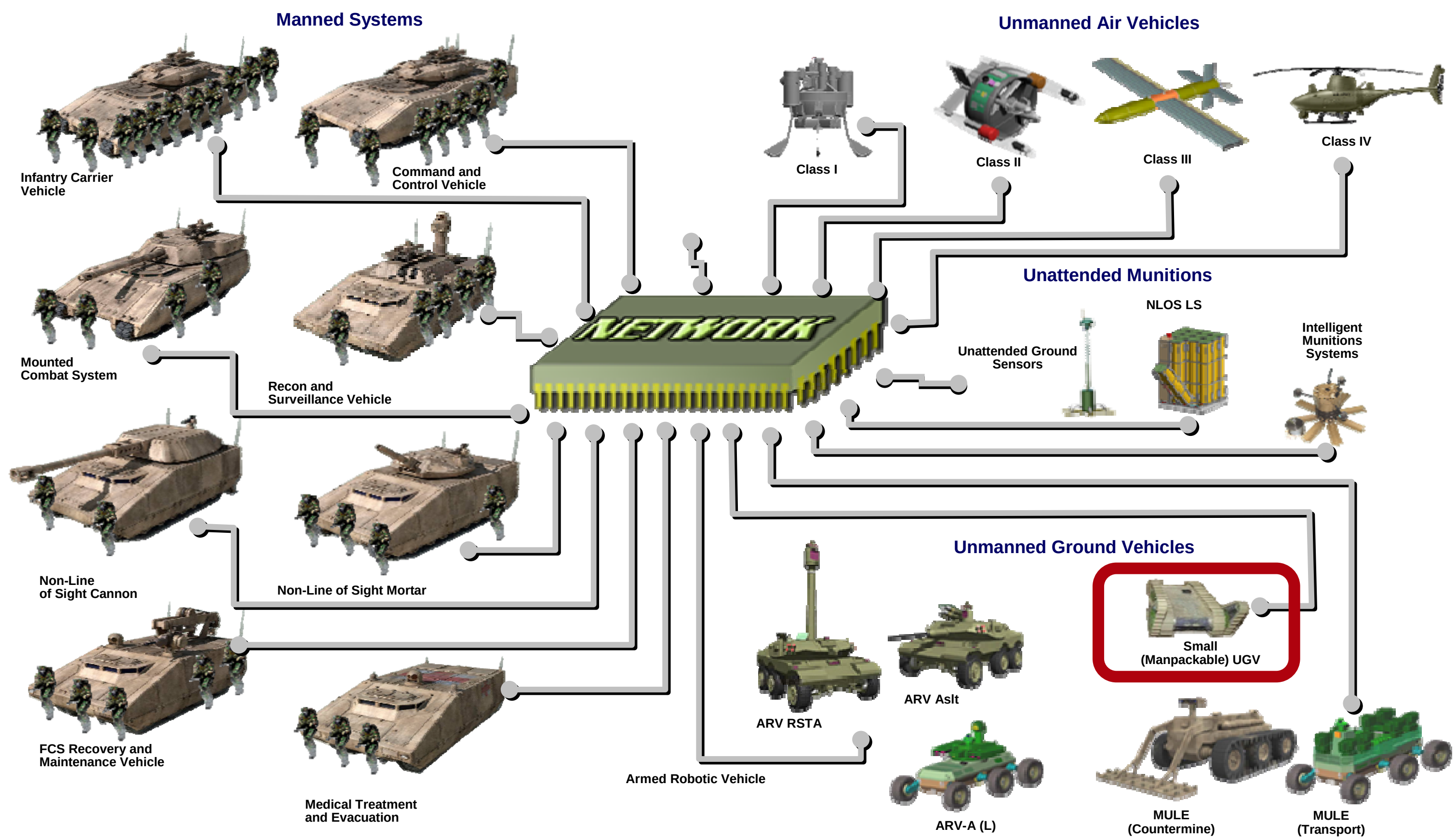




FUTURE COMBAT SYSTEMS

FCS

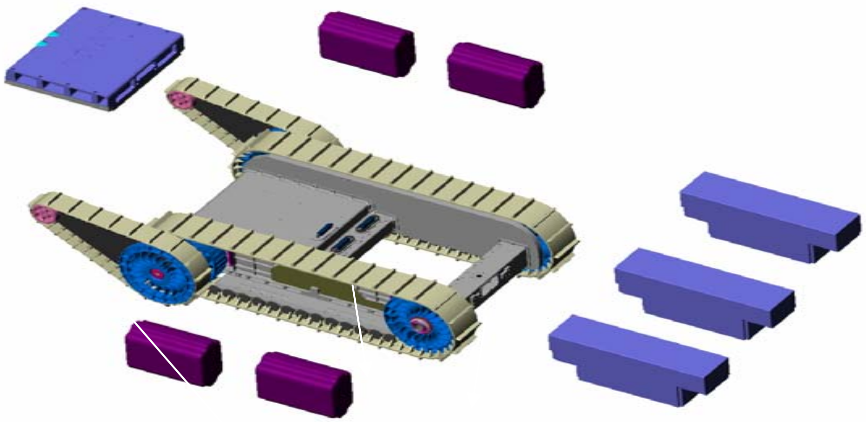
One Team-The Army/Defense/Industry



iRobot

iRobot PackBot – A Digital Machine…

- **Modular Payload Architecture**
  - 1 Front Payload
  - 4 Side Payloads
  - 3 Rear Payloads



- **Signals**
  - Ethernet
  - USB
  - Motion Control
  - Power
  - 2 Video Channels

iROBOT G&IR Division Sensor & Payload Strategy

- **We shall Shop the Market for Best in Class**
- **We will Integrate and Market 3rd Party equipment on Our Robots**
- **While We View Our Platforms as "Tightly Integrated," We are Open to Licensing Arrangements and Partnerships**
- **We will Selectively Develop Sensors & Payloads when Customers, Technology, and/or Packaging Demands**

iRobot®
NGRCV

sponsored by:
The Technical Support Working Group

Summary

$40 B
potential market opportunity in
2010

Financial Performance

Revenue Growth
Product Lifecycle Revenue

Products

Foundation

Gov. Funded R&D

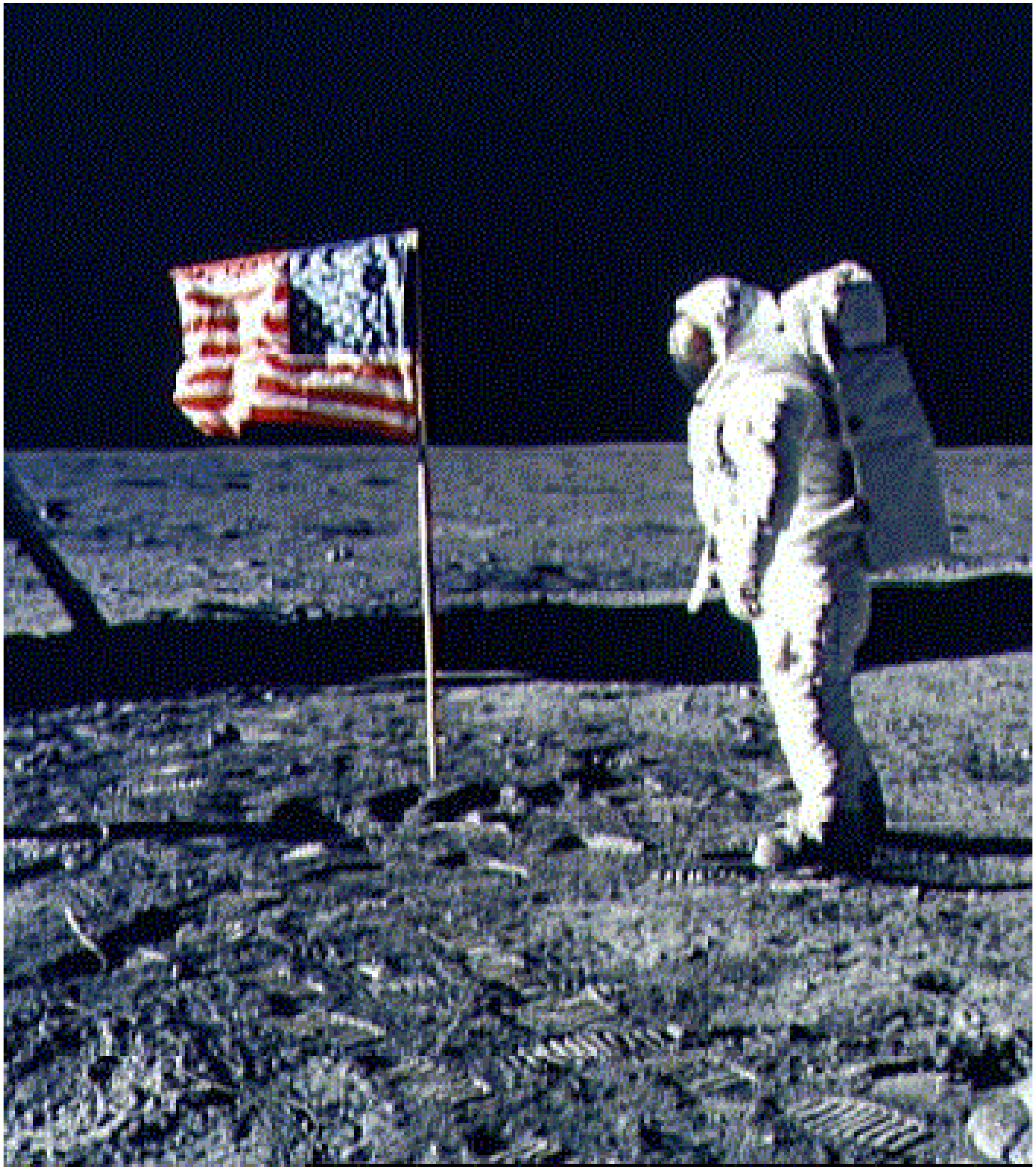
33 patents
50 pending

Multi-Disciplinary Robotic
Engineering Team
Outsourced Manufacturing

Partners

CLOROX JOHN DEERE

iRobot



Four Fundamental New Capabilities

- I. The object recognition capabilities of a two year old child
- II. The manual dexterity of a six year old child
- III. The ability to move around freely and to work in built-for-human environments
- IV. Intuitive human interfaces

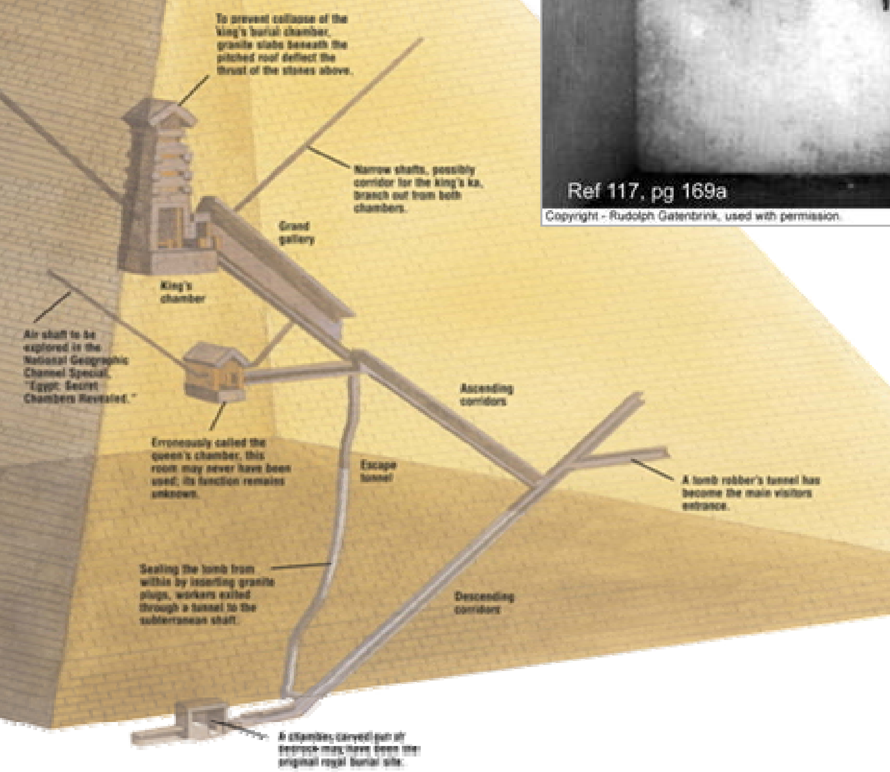
Big Application - Agriculture

- currently: roboticizing large agricultural machines
- future: maintenance of individual plants
  - pruning, picking, etc.
  - currently Europe and US import low cost labor, Japan has higher cost agriculture
  - what are the technical challenges?

Big Application - Elder Care

- currently: no automation
- future: robotic assistants
  - in-house care and nursing care
  - currently Europe and US import low cost labor, Japan is facing immediate challenges
  - what are the technical challenges?

Exploring the Great Pyramid of Giza



Copyright - Rudolph Gatenbrink, used with permission.

Computers 1978 = Robots 2001

- Locked away from public
  - too dangerous for computers
- Used inside large companies
- Operational use in military
- First few "home" computers
  - in the form of games
- Computer hacking clubs
- How-to-build-your-own books
- Undergraduate majors appearing
- First mass market "serious" home computer attempts

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- Used in manufacturing plants
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- First few "home" robots
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- IV. Intuitive human interfaces

Consequences

- Completely change the world's labor markets from the way they have developed over the last 50 years
  - change the need for low-cost labor migration
  - change the need for out sourcing low-cost manufacture
  - significantly impact the labor requirements for elder-care in societies with changing demographics
  - CHANGE THE WAY THE MILITARY OPERATES
- Create an economic tsunami that rivals or surpasses the silicon valley experience

Big Application - Agriculture

- currently: roboticizing large agricultural machines
- future: maintenance of individual plants
  - pruning, picking, etc.
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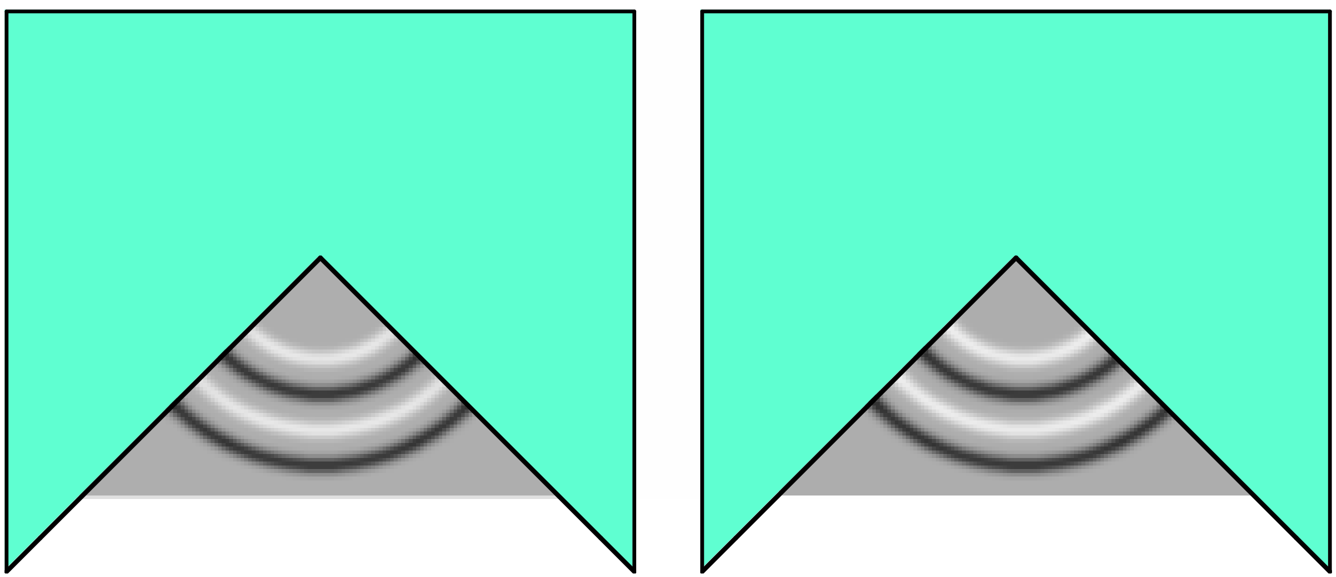
Local Ambiguity: Quadrants Same

Information must be propagated across space.



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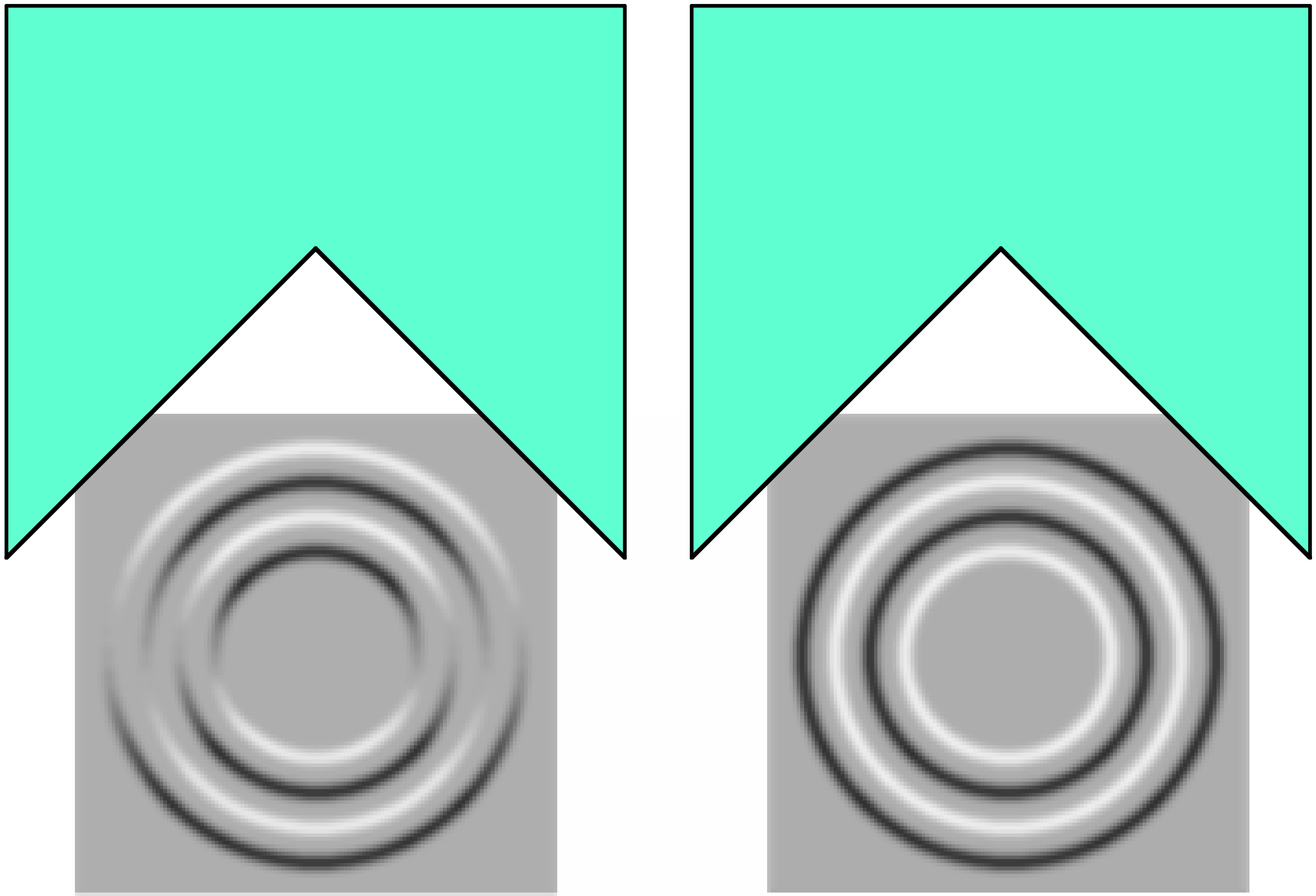
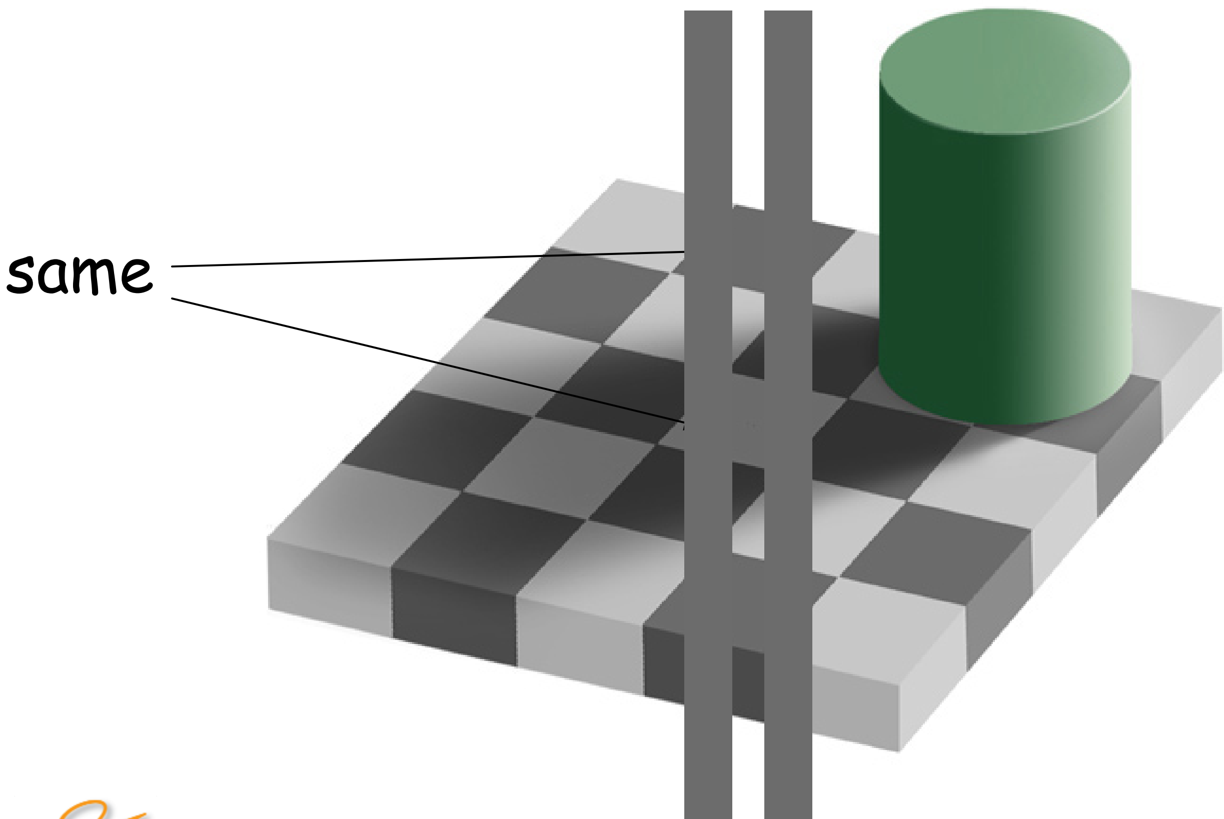


The Checkerboard "Illusion"

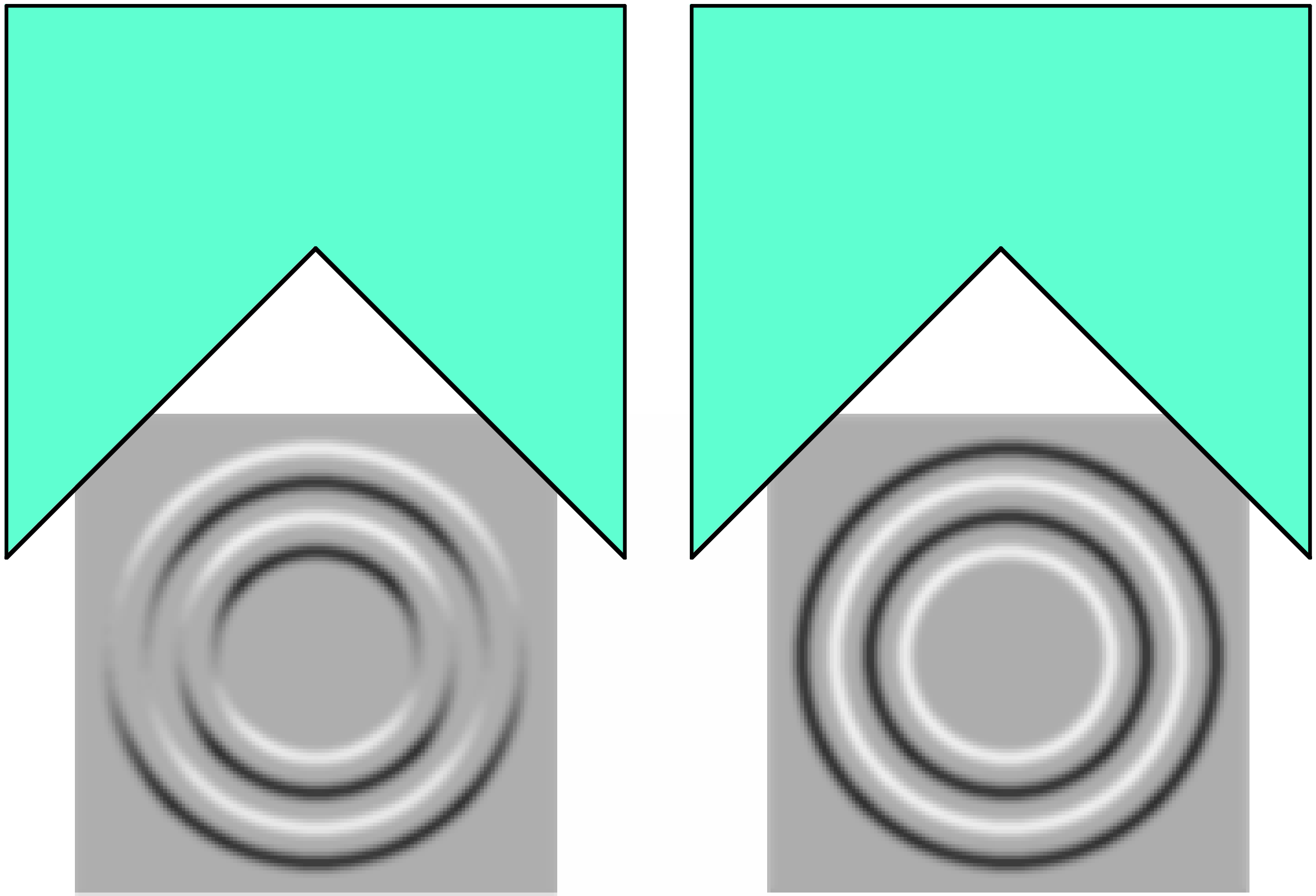


Here, the human visual system infers the color of the checks in the world, not the gray value in the image.

The "illusion" reflects the successful design of the visual system, not a quirky failure.

Local Ambiguity: Quadrants Same

Information must be propagated across space.




iRobot®


HUNTING I.E.D.'S
KHALIL GREENE PLACED ON 15-DAY DISABLED LIST AFTER

There is a Better Way

Roomba®
VACUUMING ROBOT

- Introduced in 2002
- 2 million units sold
- Strongly patented
- 1% market penetration

iRobot

Scooba

FLOOR WASHING ROBOT

- Wet scrubs hard surfaces
- 4-stage cleaning process
- Cleans better than mopping
- Recent Awards
  - Popular Science
    Best of What's New
  - Consumer Electronics Show
    Innovations award
  - Time Magazine Top Inventions

iRobot Today

- 142 Million in 2005 Revenue
- 400 Employees*
- Offices in 3 US locations + Hong Kong and India

- Over the past 3 years, shipped over $.25 Billion of robots to a diverse set of customers

Headquarters, Burlington MA, USA

Mysore, India

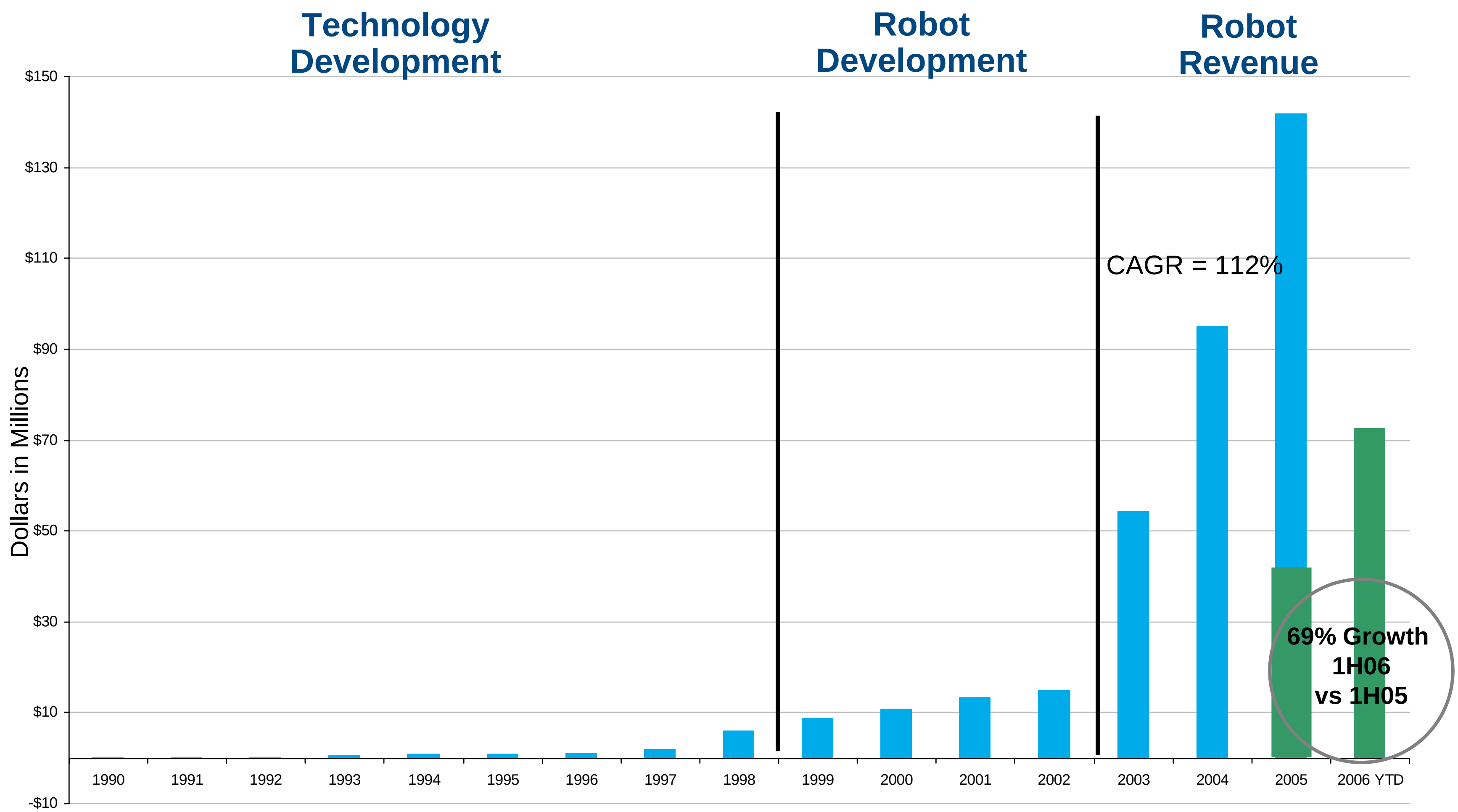
Hong Kong, PRC

San Louis Obispo CA, USA

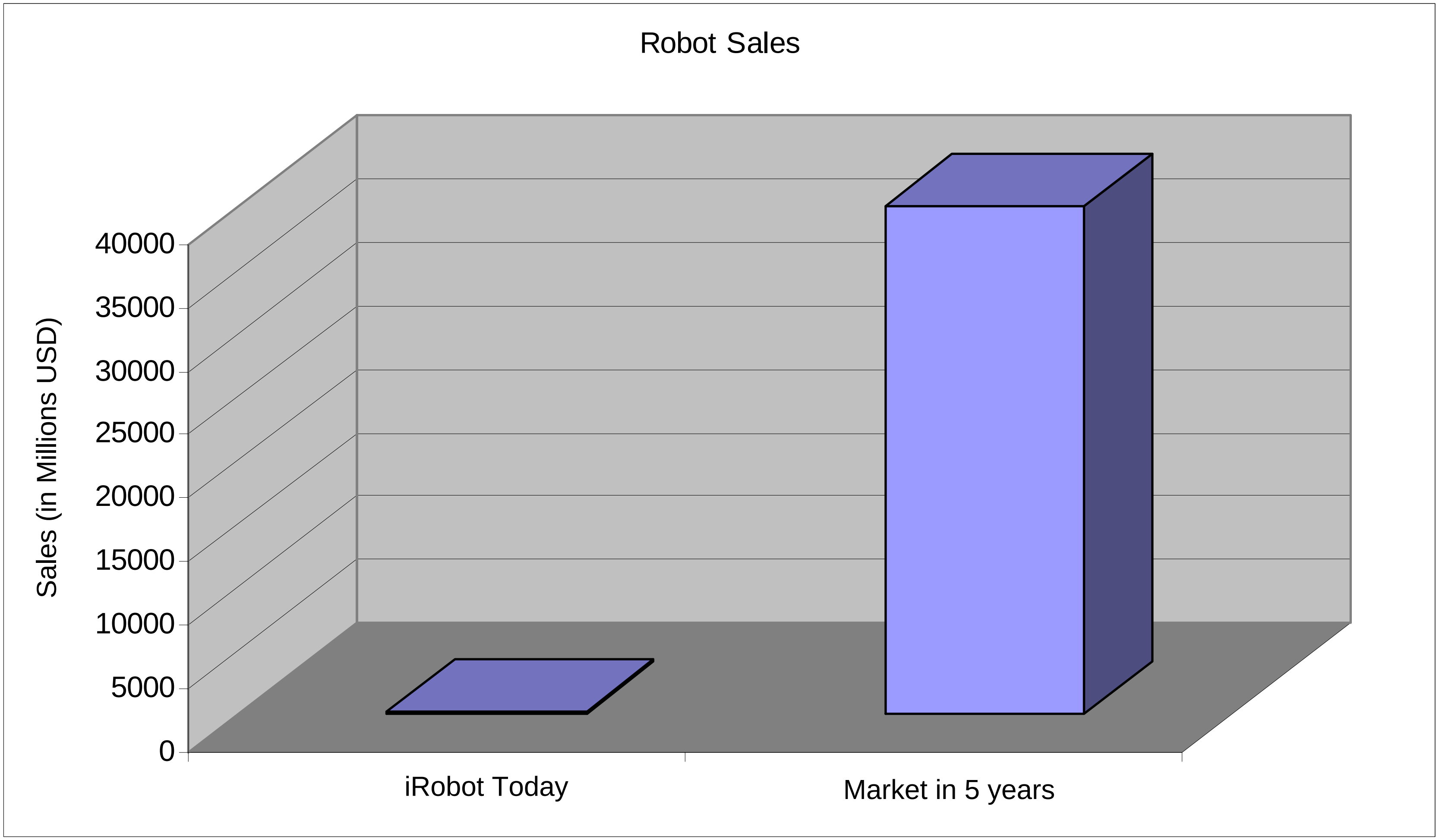
Washington DC, USA

*includes consultants and temporary employees

Explosive Revenue Growth



Market Opportunity



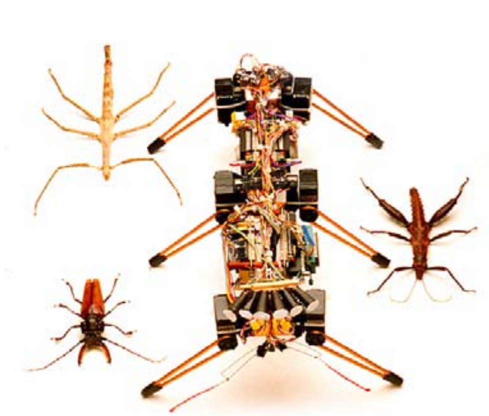
Source: Future Horizons


A PLATOON'S MISSION
SEEKING BOMBS IN DISGUISE
The New York Times
UNDER FIRE
I.E.D. HUNT
Voice of Michael R. Gordon
PLAY
PAUSED
OFF
00:41
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Sergeant Faust, right, talks to a shopkeeper about who might have planted mines.

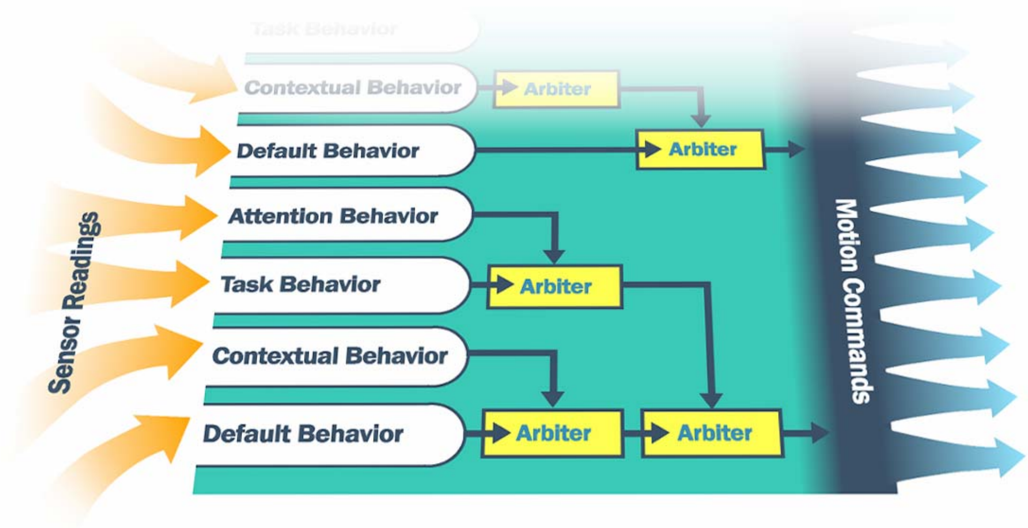
iRobot®

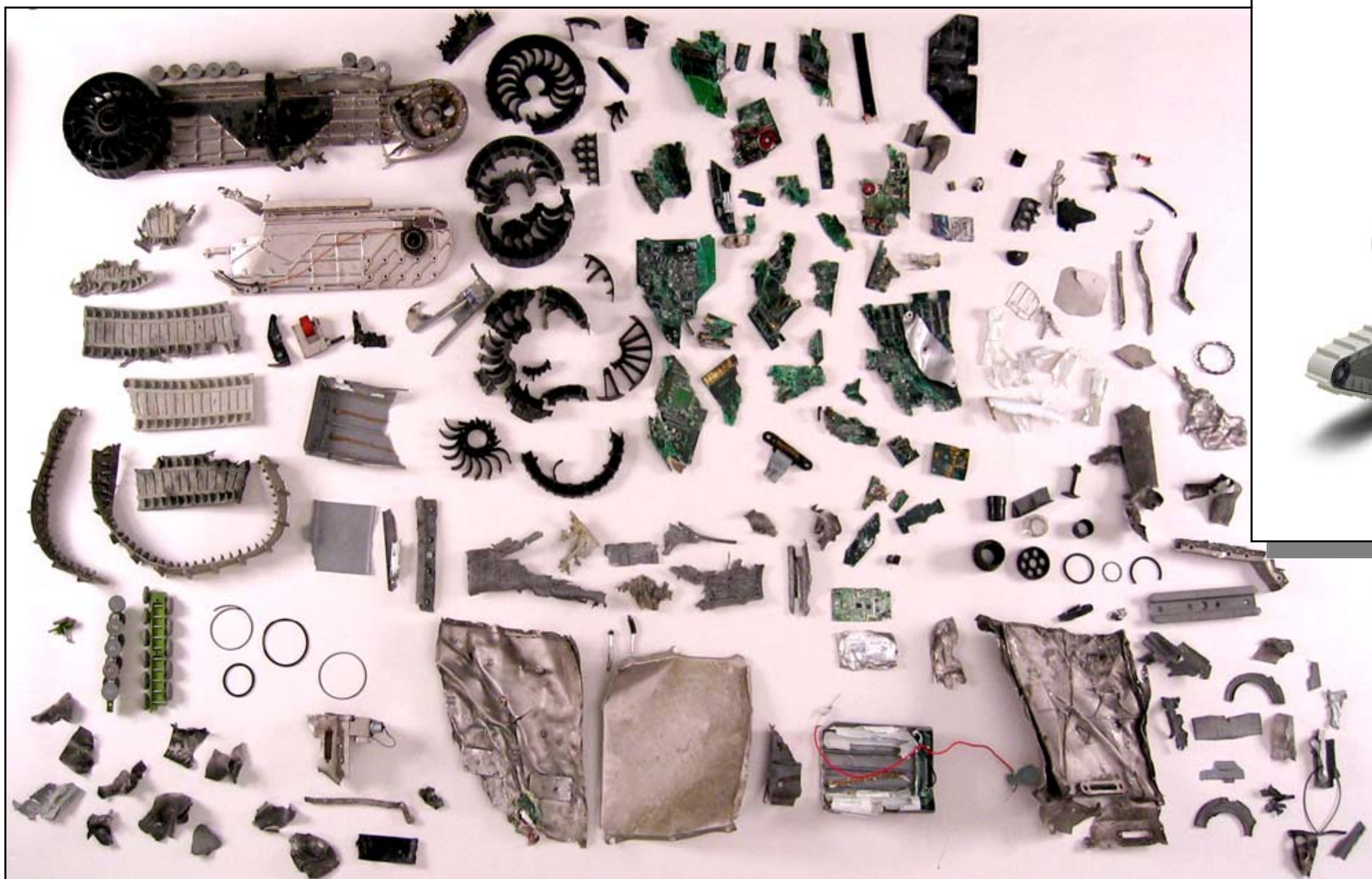
Behavior-Based Robots

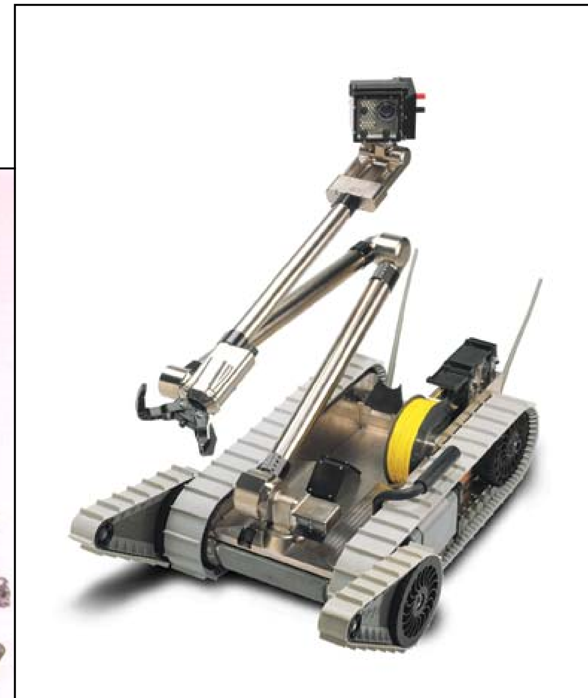
- **Fast connections between sensors and actuators**
- **Composable behaviors**
- **Multiple simultaneous goals with dynamic arbitration**
- **Dynamically variable degrees of autonomy**



Creature-like control system

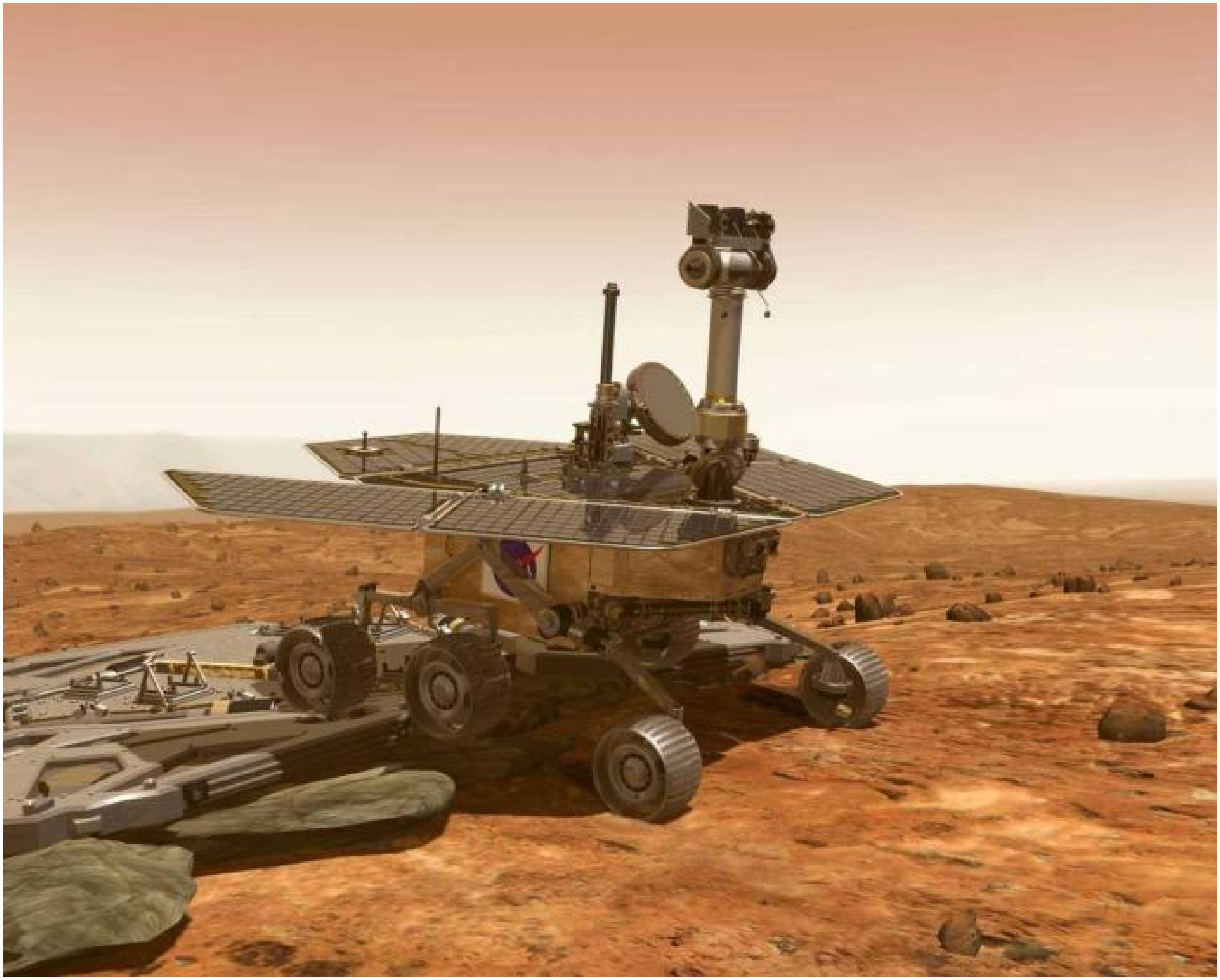






PackBot #129

Killed In Action
Iraq



Supportability & Transformation

Good sustainability requires good supportability

Bonding…

- **Tested musical theory that Vince Gill was the lead singer for Pure Prairie League on the hit "Amie"**
  - They held extensive auditions that resulted in the hiring of Vince Gill (born April 12, 1957, in Norman, OK) as lead singer and guitarist, followed by reeds player Patrick Bolin
  - http://www.answers.com/topic/pure-prairie-league
- But – learning that I must evaluate, I did further research
  - "Amie" charted in March 1975 and became a Top 40 hit. Of course, the song had been written and sung by Craig Fuller
  - http://www.answers.com/Pure%20prairie%20League

Why are We Here

- Conference theme of Sustainability
  - "Test and Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems
- Combined NDIA Committee sponsorship of T&E, Systems Engineers, and Logisticians
  - T&E Division in cooperation with…
  - Systems Engineering and Logistics Divisions…

- Will the logisticians in the room please stand up

New Requirements

DEPUTY UNDER SECRETARY OF DEFENSE FOR
LOGISTICS AND MATERIEL READINESS
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

MAR 1 0 2007

MEMORANDUM FOR UNDER SECRETARIES OF THE MILITARY DEPARTMENTS

SUBJECT: Life Cycle Sustainment Outcome Metrics

In July 2006, the Joint Requirements Oversight Council (JROC) established a mandatory warfighter Materiel Readiness/Sustainment Key Performance Parameter (KPP) (Materiel Availability) and identified Material Reliability and Ownership Cost as related Key System Attributes (KSAs) for new acquisitions. Specific definitions of these metrics, as they will appear in the revised Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3170.01C, scheduled for issuance in 1Qtr CY2007, are contained in Attachment 1.

New Metrics

- Life Cycle Sustainment Outcome Metrics
  - Material Availability (KPP)
  - Material Reliability (KSA)
  - Ownership Cost (KSA)
- Goals developed for each program early in the Concept Development process

Conference Take Aways

- Meeting sustainability standards is achievable but not free or easy
  - Lack of robust systems engineering culture
  - Cost drivers force tough decisions
  - Lack of understanding the linkage between events regardless of contract phase or funding profile

23rd Annual National Test and Evaluation Conference

Encroachment Issues Impacting the Major Range and Test Facility Base (MRTFB)

Mr. Bill Egan
Institute for Defense Analysis

March 13, 2007

The MRTFB

- **The core set of Test &Evaluation (T&E) ranges & facilities within DoD**
- **Represents a broad base of critical T&E capabilities**
- **A national asset, sized, operated, and maintained primarily for DoD T&E**
- **Available to other users (i.e., DoD, federal agencies, and allies within security provisions)**
- **Operated under uniform funding guidelines**
- **Governed by DoD Directive 3200.11**

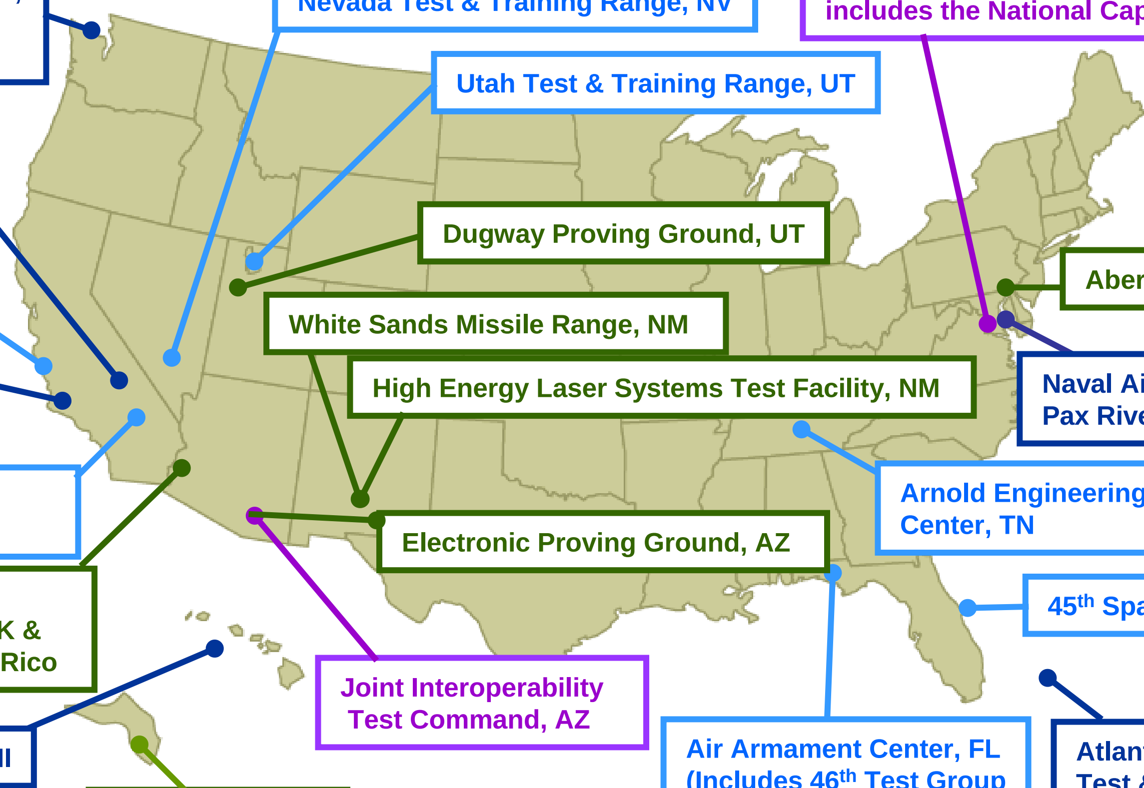
Major Range and Test Facilities Base

22 Sites: Army-7; Navy-6; Air Force-7; Defense Agency-2

30,000 personnel
Military, Gov, Contractor

18,000 sq. mi. of land
180,000 sq. mi. of air space
(> ½ of all DoD land)

Replacement Value = $25B



Legend:
Army, Navy, AF, Defense Agency

MRTFB Survey Questions on Encroachment

1. **Describe the most significant encroachment issues impacting your MRTFB**

2. **Describe any potential candidates for partnering projects in the DoD Conservation Buffer Program using DoD's authority in 10 USC Section 2684(a)?**

3. **Describe any local community or government partnerships you are actively engaged in to help resolve or mitigate your encroachment issues.**

4. **Provide any notable examples of successful proactive engagement in avoiding or overcoming a encroachment impacts.**

Survey Question One

1. Describe the most significant encroachment issues impacting your MRTFB.

MRTFB Encroachment Responses to Survey

Service	MRTFB	Env	FS	US	N&C	RL	AS	ENG	SR	UDA
Army	APG	X	X	X		X				
	DPG									
	EPG	X	X	X	X		X			X
	HELSTF									
	KWAJ									
	WSMR	X	X	X	X		X			X
	YPG	X	X	X	X	X	X			X
Navy	AUTEC	X	X	X						
	KEYPORT	X	X	X	X	X			X	
	NAWC PR	X	X		X	X	X	X	X	
	NAWC CL	X	X	X	X	X	X	X		
	NAWC PM	X	X		X	X		X	X	
	PMRF	X		X	X				X	
Air Force	30th SW	X	X	X	X	X	X	X	X	
	45th SW	X	X		X			X	X	
	46th TW/TG	X	X	X			X	X		X
	AEDC	X		X	X	X				
	AFFTC	X	X	X	X	X	X	X		
	NTTR	X		X	X	X	X	X		
	UTTR	X	X	X		X	X	X		
Agency	JITC		X							
Totals	21	17	15	14	13	11	10	9	6	4

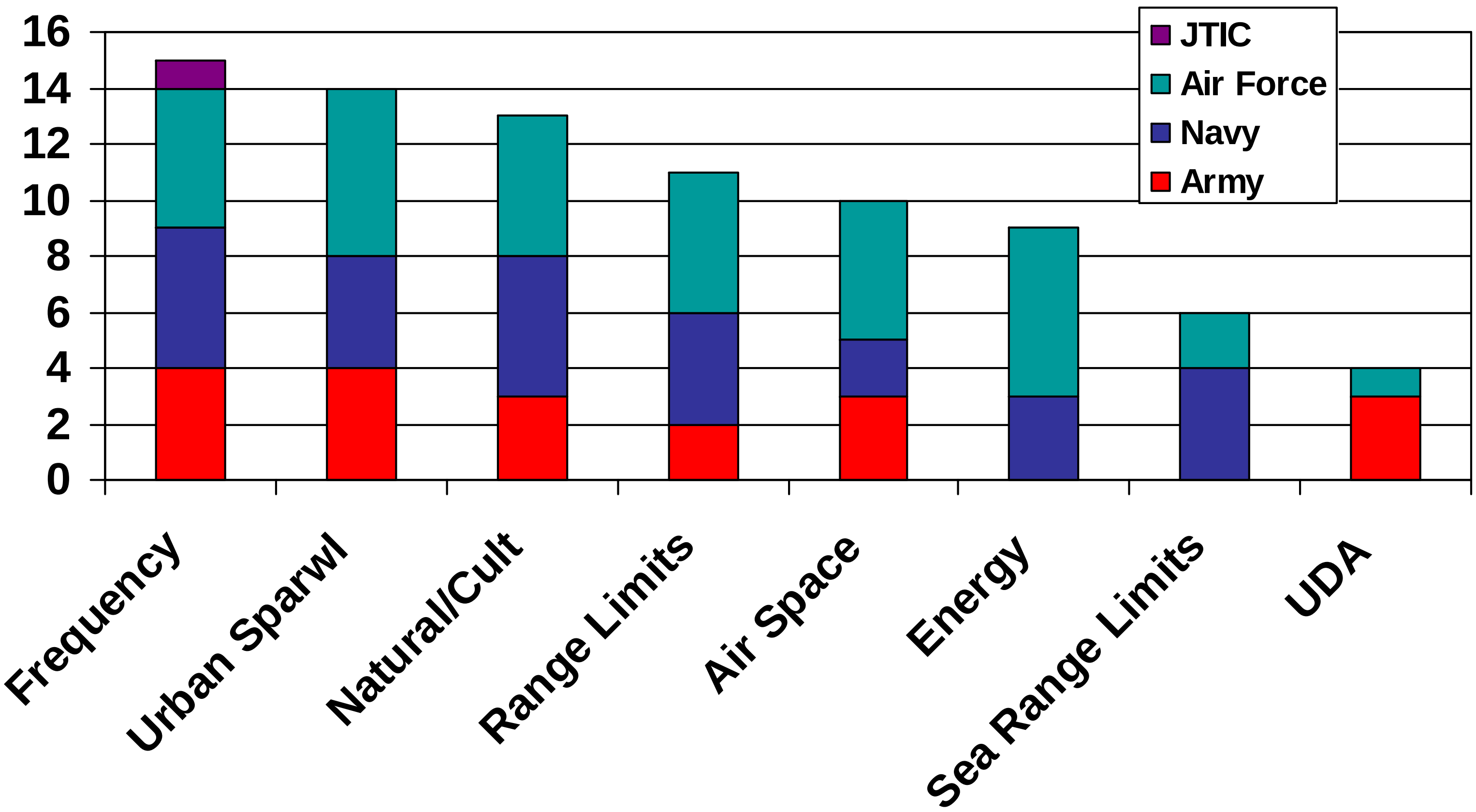
ENV=Environmental*
FS = Frequency Spectrum
US = Urban sprawl
ENG = Energy
NC = Natural & Cultural

AS = Air Space
RL = Range Limitations
SR = Sea Range Limitations
UDAs = Undocumented Aliens

RED =	Most Significant Encroachment		
FS =	8		
US =	6		
ENV =	2		

* Environment = anomaly data point

Reported Sources of Encroachment

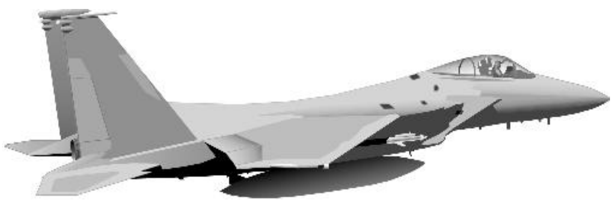


Two Major Encroachments

- Frequency Spectrum
- Urban Sprawl

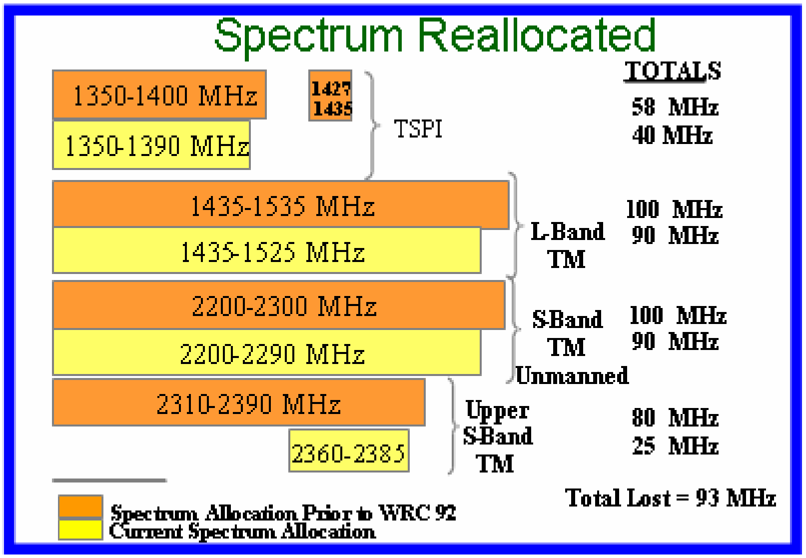
Increasing Demands for Radio Frequency (RF) Spectrum

Increasing demand for bandwidth and decreasing available spectrum; RF interference from/with commercial and unlicensed users.



In 1986, the data rate for the F-15 was 256 Kbps

In 1997, the data rate for the F-22 was 5 Mbps



Frequency Spectrum Example

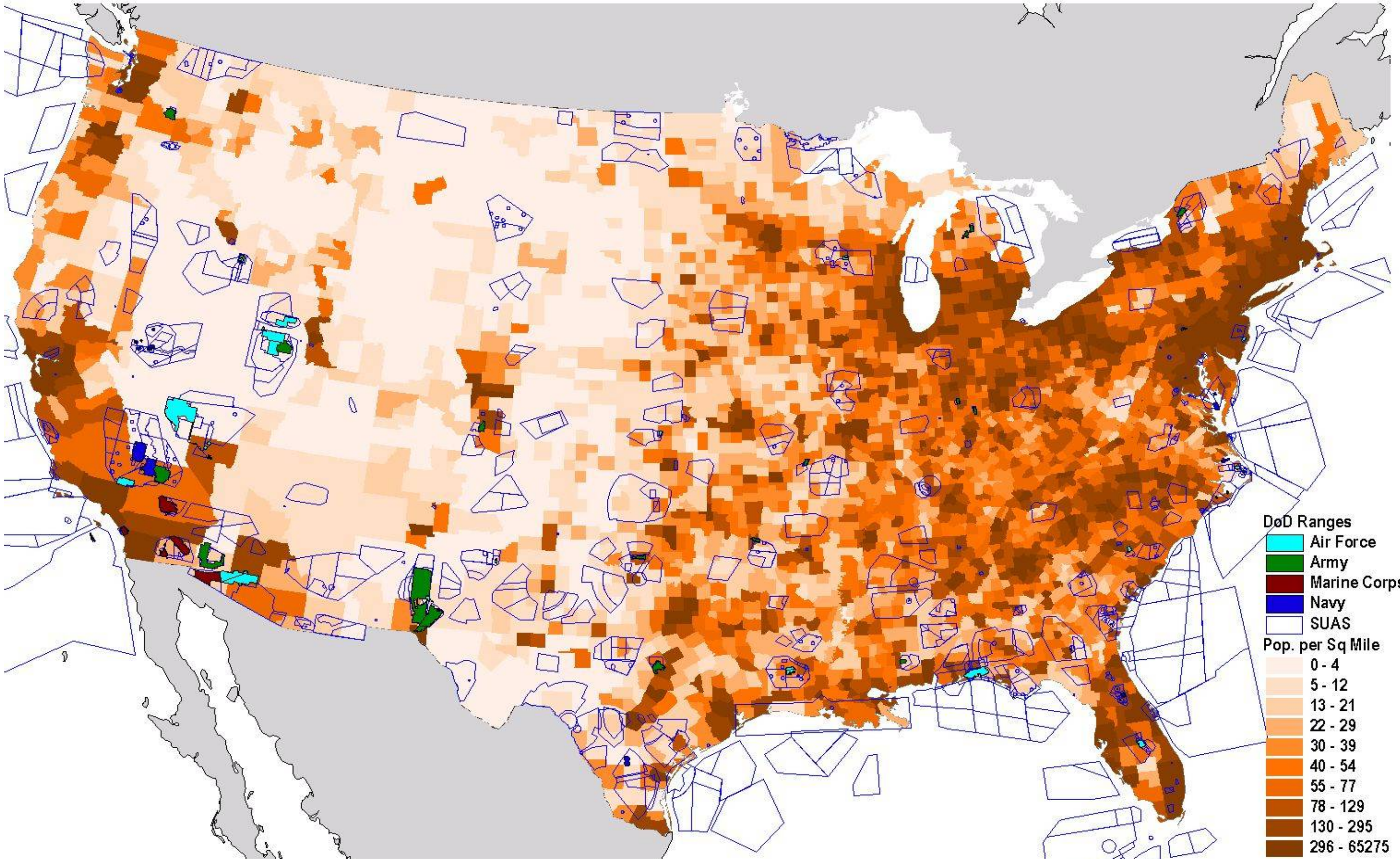
- **22 Examples Reported**

- **15 MRTFB's Responded with similar issue.**

  "Our crucial electromagnetic spectrum assets are continuously threatened with reallocation to non-Government usage to bring in auction profits to the US Treasury. The MRTFB frequency bands that remain are being encroached upon by billions of unlicensed/low-powered commercial Part 15 Devices"

Increasing Urban Sprawl

Development of adjacent private and public lands, and commercial developments such as condominiums, air fields and recreation facilities



Urban Sprawl Examples

- **25 Examples Reported**
- **NAWCWD-CL: “Urban growth within the R-2508 Complex and within the boundaries of IR-200, could also negatively impact the NAWCWD-CL mission.**
- **46th TW/TG Condominium development along the Gulf coast if the height impacts instrumentation line-of-sight over the Gulf of Mexico.**
- **NTTC Nellis AFB’s ability to perform its mission is endangered by the ever increasing pressure of urban encroachment. Development can threaten or have the potential to threaten current and forecasted Air Force mission requirements at Nellis AFB (NAFB), Creech AFB (CAFB) and the Nevada Test and Training Range (NTTR) if the type of development is non compatible with the military mission.**

Survey Question Two

2. **Describe any potential candidates for partnering projects in the DoD Conservation Buffer Program using DoD's authority in 10 USC Section 2684(a)?**

Buffer Partnership Examples

- **14 Examples Reported**
- **AFFTC We have a significant candidate project for partnering under the provisions of 10 USC Section 2684(a) – The R-2508 Sustainability Plan. The focus of this plan is to protect the most critical operating areas within the R-2508 from a joint (tri-service) perspective. Currently three sub-projects have been prepared within the R-2508 Sustainability Plan.**
- **APG is currently partnered with Harford County Land Trust for the Army Compatible Use Buffer (ACUB). Land has been secured surrounding the DOD's only hilly, cross-country automotive test track which has been in operation for over 60 years.**

Survey Question Three

3. **Describe any local community or government partnerships you are actively engaged in to help resolve or mitigate your encroachment issues.**

Community Partnership Examples

- **57 Examples Reported**
- **30th SW agreements with various organizations for the evacuation, sheltering, or closure of local public and private population centers surrounding Vandenberg AFB,**
- **YPG west of the YPG Laguna/Cibola Area with the State land near Martinez Lake on the Colorado River--attempts in the past of private citizens attempting to purchase State land for putting in an airfield within restricted airspace. YPG worked closely with the State to disapprove this action.**

Survey Question Four

4. **Provide any notable examples of successful proactive engagement in avoiding or overcoming encroachment impacts.**

TEST RESOURCE MANAGEMENT CENTER
DEPARTMENT OF DEFENSE

Proactive Engagement Examples

- **68 Examples Reported**
- **AEDC There is a very active Arnold Community Council that provides an avenue to address any encroachment issues.**
- **AFFTC partnership with the wind industry to help guide development away from our most critical operating areas.**
- **APG has an active Noise Monitoring program. Monitors are in place in a 4-county area around Aberdeen Proving Ground and are constantly monitored.**

What Can We Do About It?

- **Passive Involvement**
- **Proactive Involvement**

In Trouble?? (Passive Involvement)

Act Like You Know What You Are Doing and Keep Going

Proactive Involvement

- **Addressing Frequency Spectrum Encroachment**
  - Central T&E Investment Program (CTEIP) investments
    - Spectral Efficiency Technologies
  - Range Spectrum Requirements Working Group (RSRWG)
  - World Radiocommunication Conference (WRC) 2007 Agenda Item 1.5
    - Competing globally for additional spectrum
  - DoD Spectrum Office, ASD(NII)
    - Developing strategic plan for spectrum

- **Addressing Urban Sprawl**
  - FY2003 National Defense Authorization Act (NDAA) – Authority for Military Departments to partner with state and local governments and not-for-profit land trust associations to acquire easements and other interests in lands adjacent or in the vicinity of military installations.
  - DoD Readiness and. Environmental Protection Initiative (REPI)
    - DoD Conservation Buffer Program
      Per 10 USC Section 2684(a)
      - Very Successful Program
      - Need more Test Range Participation

Backup

BACKUP SLIDES

RRPI Successes to Date

- Five of eight RRPI provisions have been enacted:
  - MBTA Military Exemption
  - MMPA Harassment
  - ESA Critical Habitat
  - Conservation Partnering (buffers)
  - Surplus Land Disposal

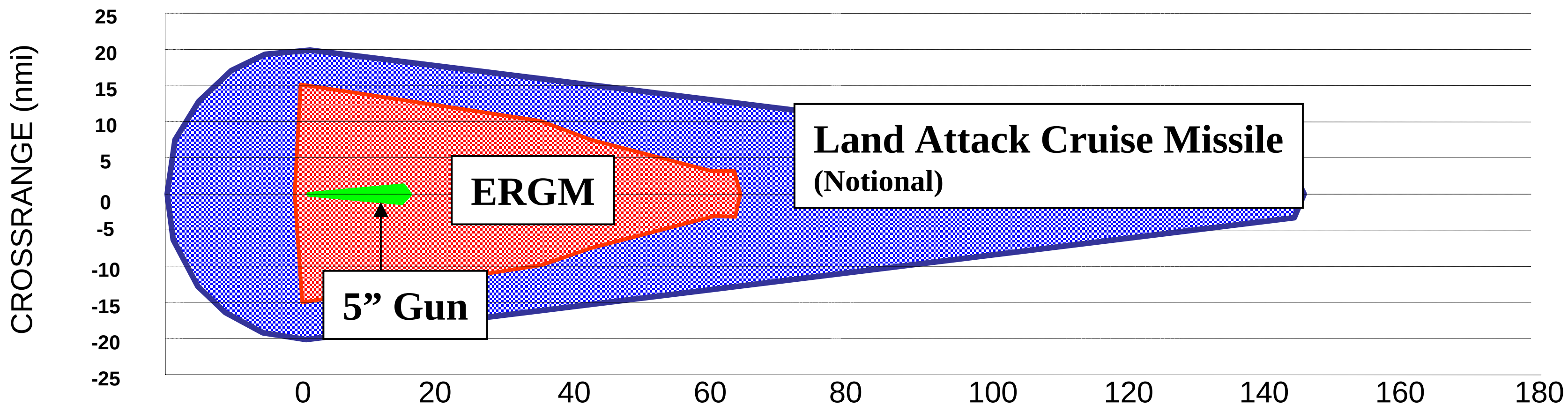
- Benefits to DoD are tangible
  - MBTA – Permanent USFWS rule codifying exemption now in place
  - MMPA – Has increased some exercise and training flexibility at sea (but other challenges remain)
  - ESA Critical Habitat – Ranges now preserving endangered species under terms of their INRMPs instead of with newly declared critical habitat
  - Conservation Partnering / Buffer program has leveraged DoD funding and established win-win strategic partnerships. Significant acres of land already under 2684a conservation to DoD benefit.

MRTFB Survey Responses

- **Environmental—17**
  - Army - 4
  - Navy - 6
  - Air Force - 7
- **Frequency Spectrum—15**
  - Army - 4
  - Navy - 5
  - Air Force -5
  - JTIC -1
- **Urban Sprawl—14**
  - Army - 4
  - Navy 4
  - Air Force - 6
- **Natural & Cultural Resources -13**
  - Army - 3
  - Navy - 5
  - Air Force - 5
- **Range Limitations - 11**
  - Army - 2
  - Navy - 4
  - Air Force - 5
- **Air Space - 10**
  - Army - 3
  - Navy - 2
  - Air Force - 5
- **Energy Projects - 9**
  - Army - 0
  - Navy - 3
  - Air Force - 6
- **Sea Space Limits - 6**
  - Army - 0
  - Navy - 4
  - Air Force - 2
- **Undocumented Aliens - 4**
  - Army - 3
  - Navy - 0
  - Air Force - 1

Increasing Footprint to Support T&E

Increasing three dimensional foot print requirements for evolving faster, longer range weapon systems; environmental concerns and urban development initiatives that restrict airspace use



Increasing Energy Demands

Off-shore drilling platforms, wind energy wind mills, Liquid Natural Gas (LNG) transport and storage, mandated energy corridors

Proposed Energy Corridors; initially 11 Western States; Soon National Footprint

Increasing Demands to Protect Natural and Cultural Resources

Existing and newly established national monuments, water recreation sites, parks, forests, sacred lands and archeological sites

Examples

30th SW: Point Conception Lighthouse – Acquisition of a decommissioned lighthouse (30 acre parcel) from the U.S. Coast Guard will prevent private ownership of the property, where the AF operates a radar system in support of MRTFB operations.

AFFTC: Supersonic and low-level operations can generate pressures from the public to curb operations or conduct them in other areas. An example of this is the operation of parks and wilderness areas.

NAWCWD-CL China Lake: There are literally thousands of archeological sites on the ranges at China Lake. They require substantial management effort and financial support, primarily for surveys.

NAWCWD-PM: California Coastal National Monument – The California Coastal National Monument was created in January 2001. It designates all the rocks along the California shoreline as a national monument under the Bureau of Land Management (BLM). The rocks around San Nicolas Island are included.

Increasing Demands on Air Space

Los Angeles Air Traffic Control Center has reported record traffic counts over the last year. The R-2508 airspace is surrounded by three of the top ten busiest airports in the country; San Francisco bay area to the north, Las Vegas to the east, and Los Angeles basin to the south.

Examples

AFFTC: Airspace is a sought-after commodity, from other DOD Services, commercial and private sources.

NAWCWD-CL: Initial planning for a new airport to serve Las Vegas is underway.

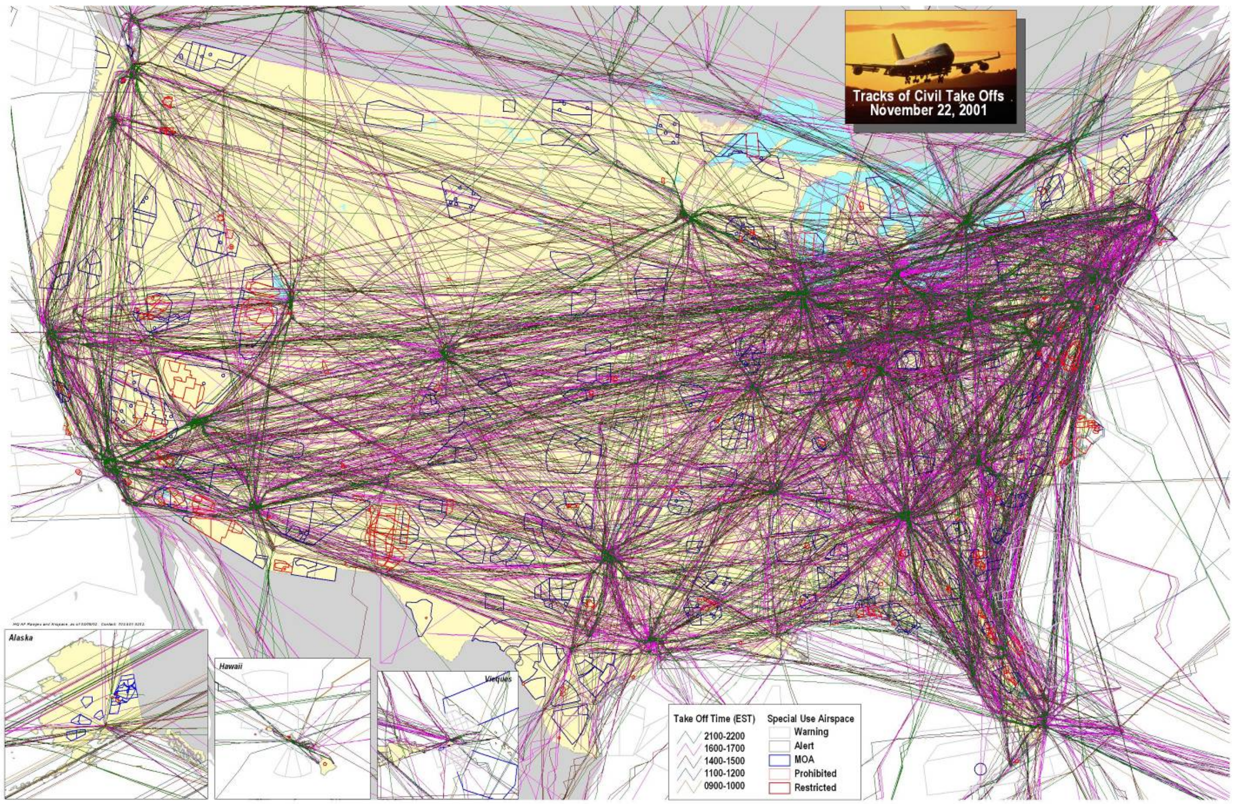
UTTR: Overflights, deviation requests and denial of R-6404D at required altitudes continues to be a challenge to ensure UTTR MRTFB mission accomplishment

EPG: The FAA has ruled against UAV flight outside of restricted airspace.

NAWCAD-PR: Pressure from increased private and commercial flights (Eastern Shore and SUA Spill-in)

Increasing Demands for Air Space

Increased commercial demand for airspace, long haul and terminal, at all altitudes;
Results in restrictions on DoD Special Use Air Space



Cost to FAA
$174M through 2005
Est $35M Annually
2006-2008

Savings to flying industry
$117M annually in 2003
$364M annually in 2008

Increasing Demands on Range Space

Examples:

NAWCAD-PR: Reduced access to land based targets and surface operating areas at the Bloodsworth Island Range results in a loss of potential capabilities and benefits.

UTTR: Large footprint weapons require additional property be considered when preventing physical encroachment.

YPG: Cold Regions Test Center's (CRTC's) largest encroachment comes from other Army units. US Army, Alaska (USARAK) has increased in size with the drawdown of OCONUS units. With this increase in size came an increase in the amount of training conducted in the same areas as CRTC uses for testing.

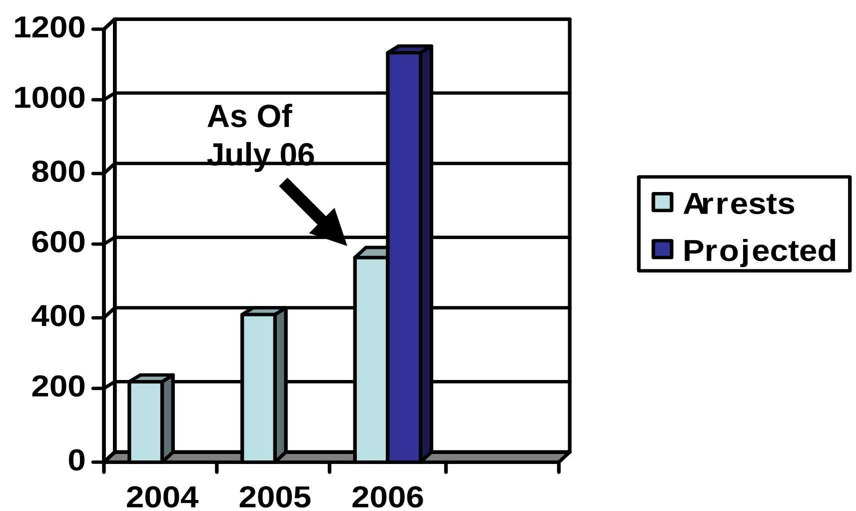
NAWCWD-CL: Urban growth within the R-2508 Complex and within the boundaries of IR-200, could also negatively impact the NAWCWD-CL mission. (IR-200 is the corridor used for testing cruise missiles fired from the Sea Range to the China Lake Land Ranges and is the only such corridor on the West Coast.)

NAWCWD-PM: Channel Islands National Marine Sanctuary (CINMS). The Sea Range encompasses the CINMS, one of fourteen national marine sanctuaries managed by NOAA. As part of the CINMS Management Plan update, NOAA has proposed expansion of the sanctuary along with changes to the regulations that address military activities.

Increasing T&E Safety & Security Concerns from Trespassing Aliens

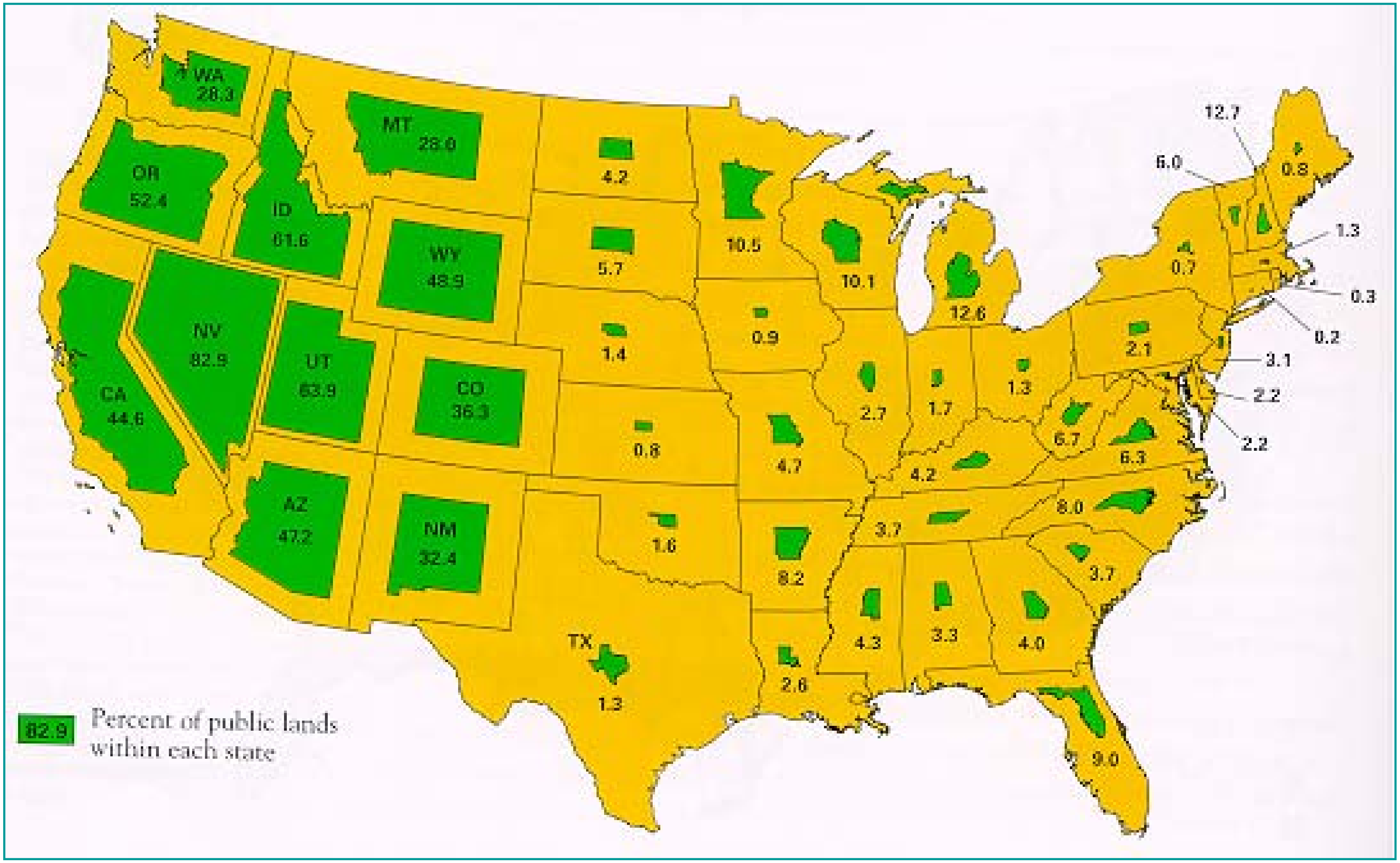
<u>Undocumented Aliens (UDA's)</u>— Danger to undocumented Immigrants trespassing MRTFB site areas adjacent to foreign borders.

YPG Data



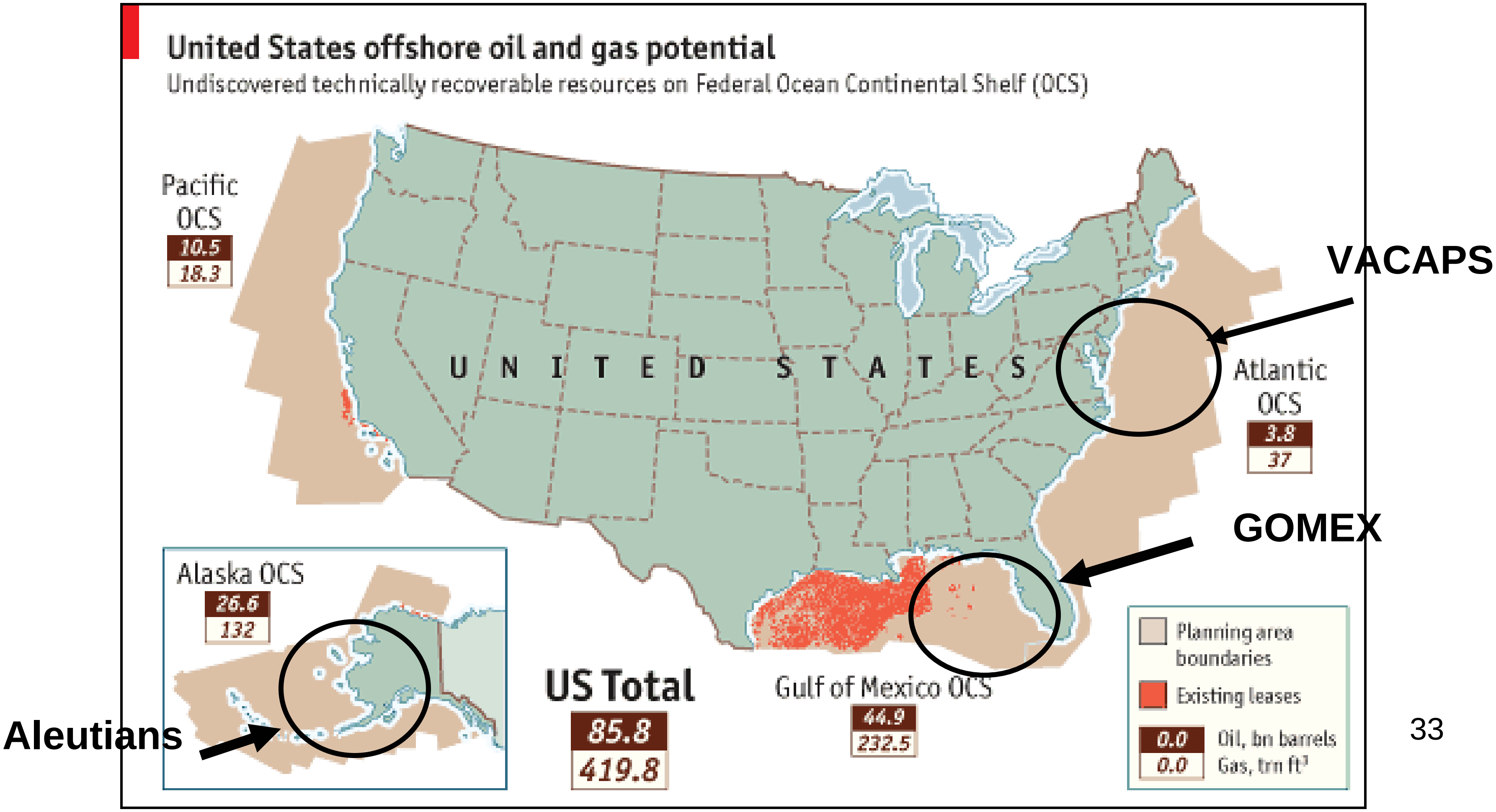
Increasing Urban Sprawl

Less Available Public Land



Increasing Energy Demands

Navy serving as DoD lead for negotiations with DOI on Outer Continental Shelf and future year oil & gas exploration and drilling leases. Eglin Range threatened but proactive for compatible use. New leases authorized for VACAPES and Aleutians



Low-Cost Epoch-by-Epoch™ Network-Centric Positioning Unit (ENPU) for FCS Testing

23rd Annual National Test & Evaluation Conference

Hilton Head Island, SC

March 12-15, 2007

Presented by:

Dr. Jeff Fayman

Geodetics Incorporated

About Geodetics

Geodetics, Inc. is a Woman Owned Small Business (WOSB) based in San Diego, California.

Geodetics specializes in high-precision, real-time position and navigation solutions based on its proprietary **Epoch-by-Epoch™** technology.

Geodetics offers a full range of GPS based products and services.

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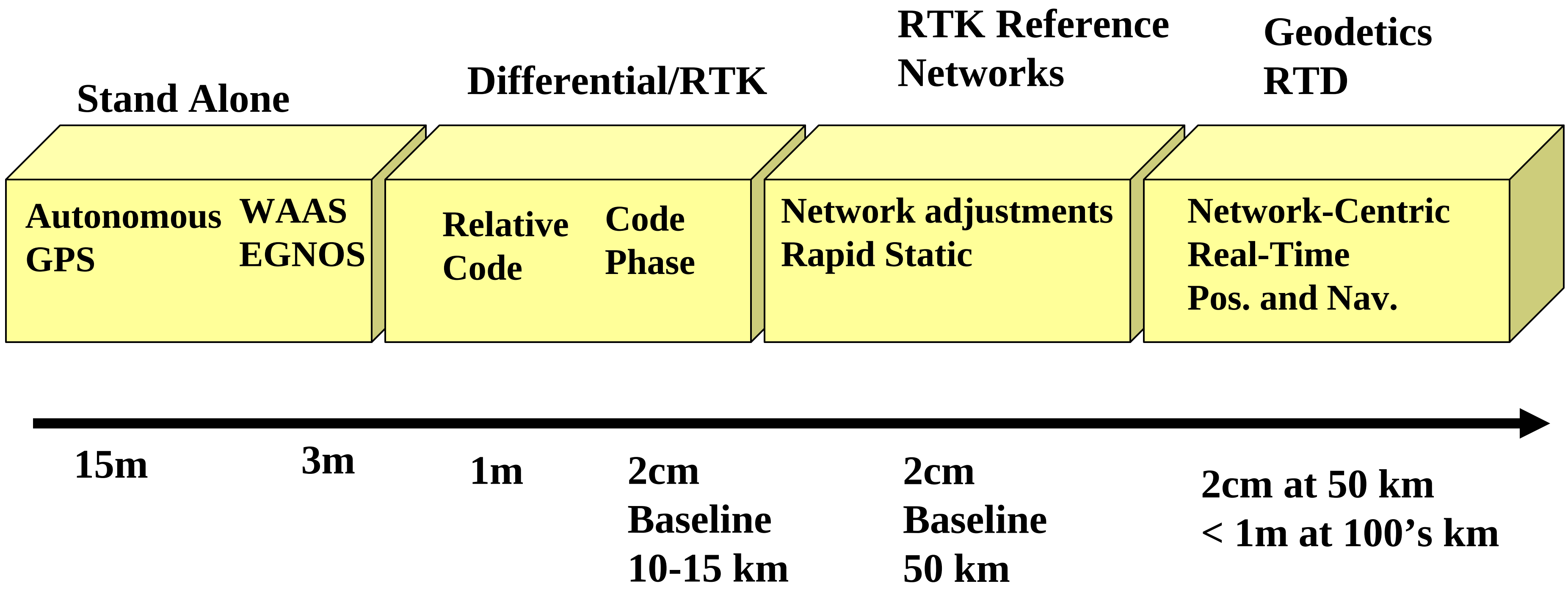
Real-Time Dynamic (RTD) Technology



Geodetics is Introducing Real-Time GPS Reference Network Technology to the Army at Ft. Bliss and Ft. Hood. And the Navy at SPAWAR.

This Technology has been Deployed in many Civilian Applications World-Wide

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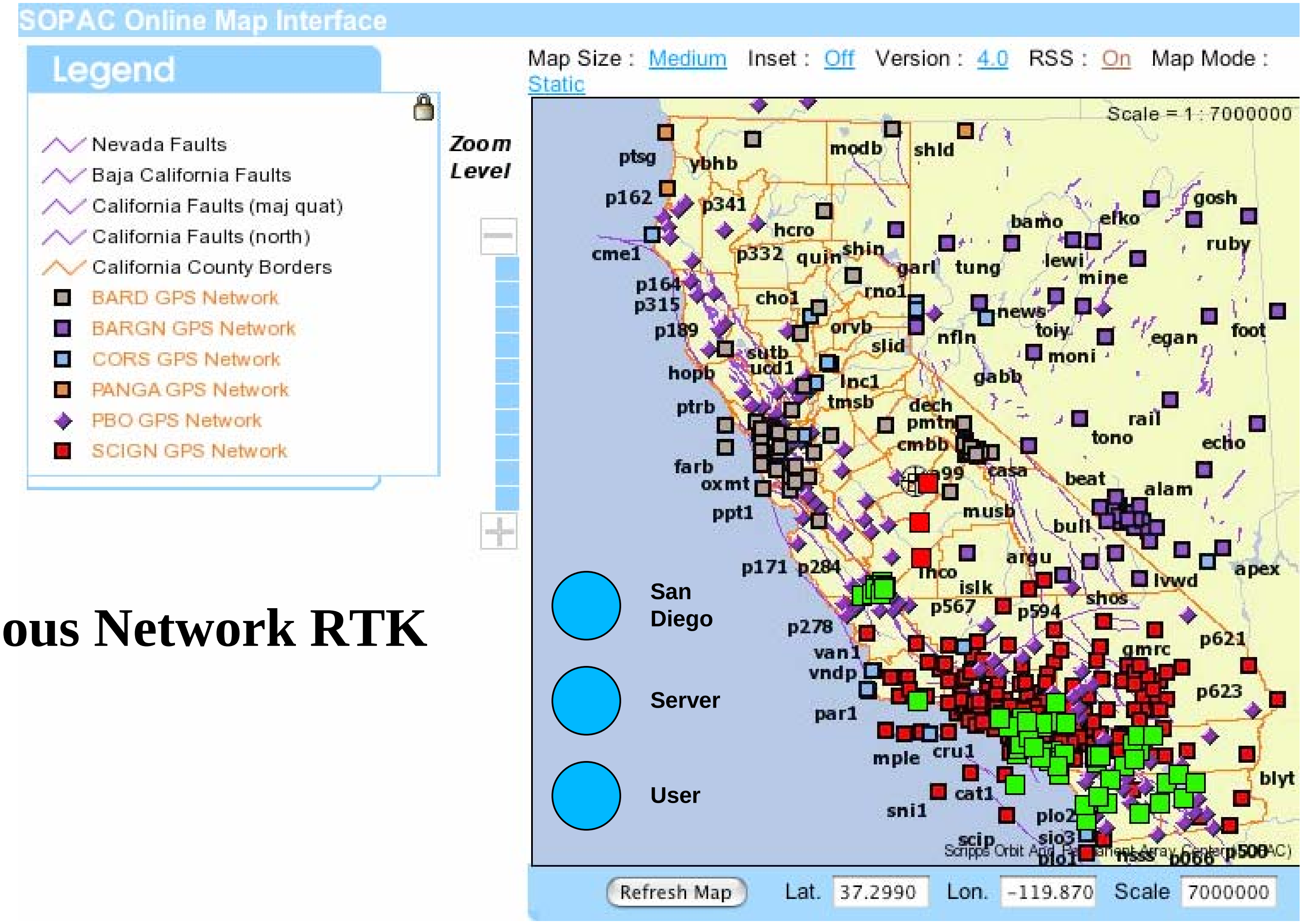
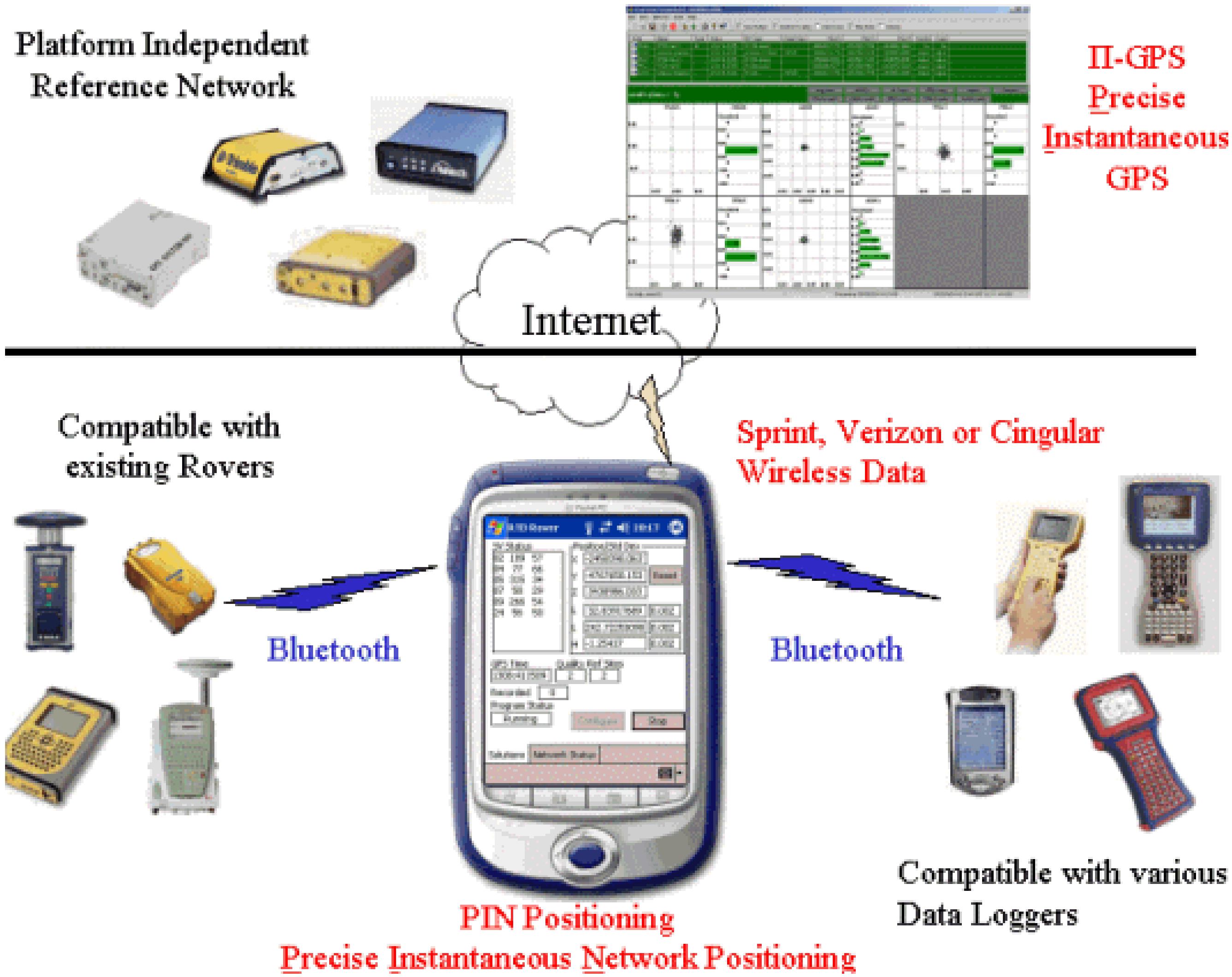
California Real-Time Network (CRTN)



Instantaneous Network RTK

Geodetics Total Solution (Civilian)



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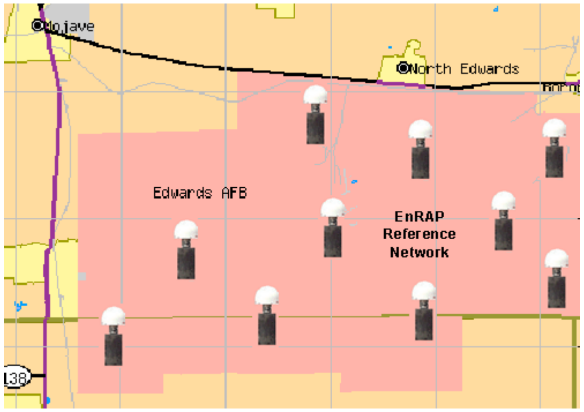
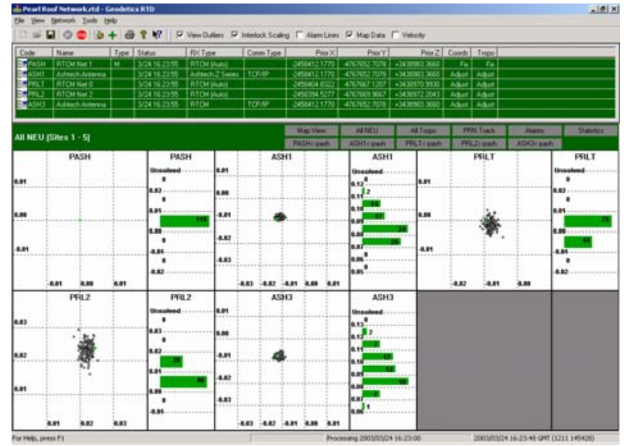
Real-Time GPS Reference Network

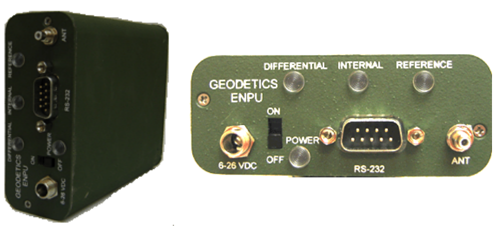


Reference Network

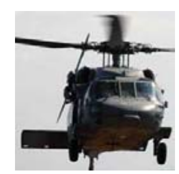


Reference Network
Management System

Data-
Link



Epoch-by-Epoch™ Network-Centric
Positioning Unit (ENPU) for
Dismounted Soldier and Low-Dynamic Vehicles



Participants

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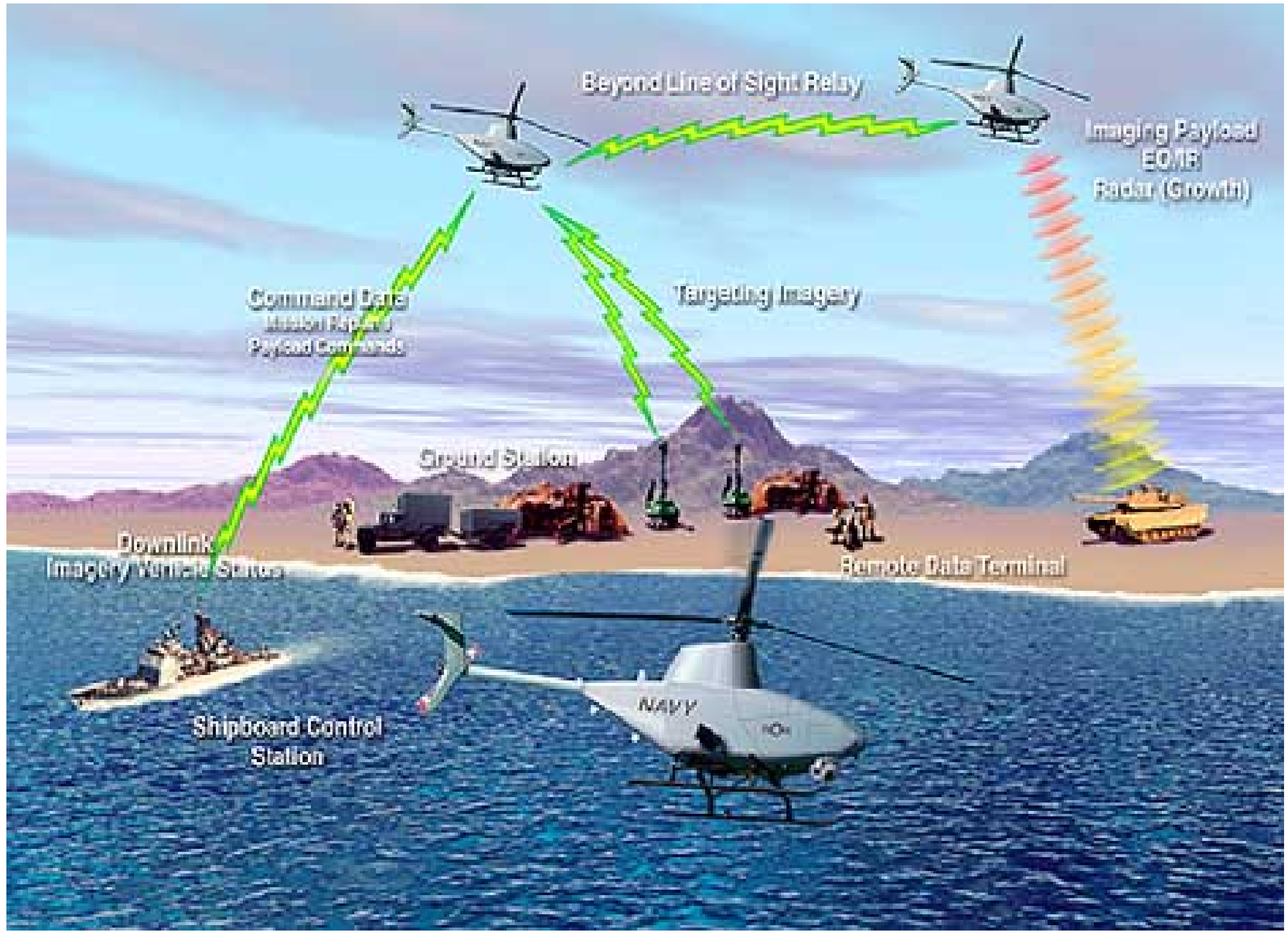
Real-Time, High-Accuracy Network-Centric Positioning for Mobile Force

Epoch-by-Epoch™ technology embedded in rovers offers real-time centimeter level relative and absolute positioning of many players.

The reference network enables extended range operations of the players and centralized command and control through Geodetics RTD server.



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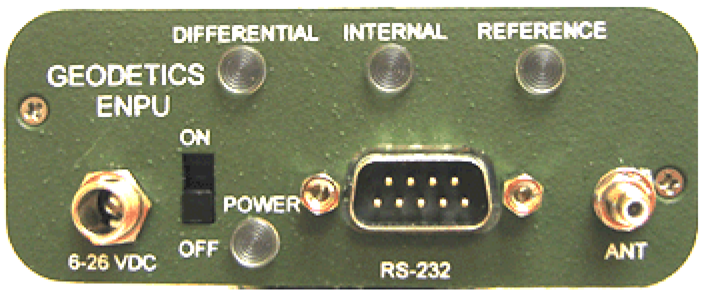
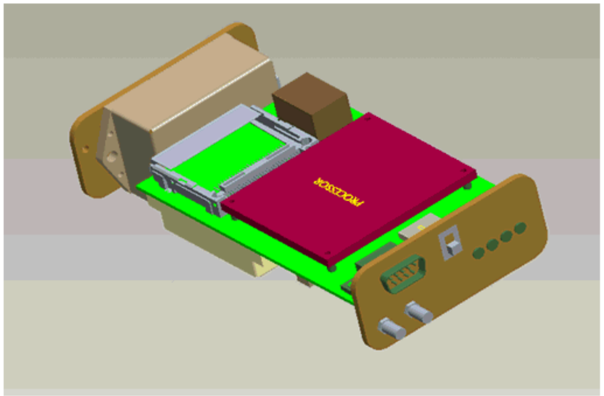
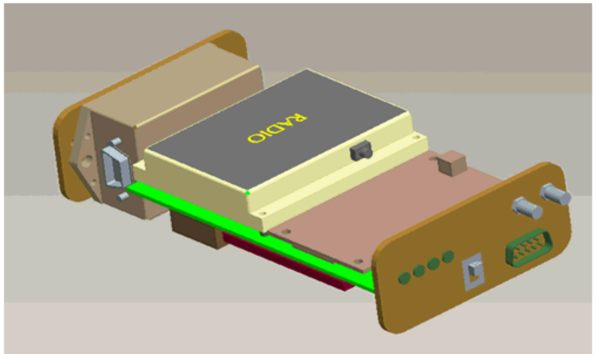
Epoch-by-Epoch™ Network-Centric Positioning Unit (ENPU)







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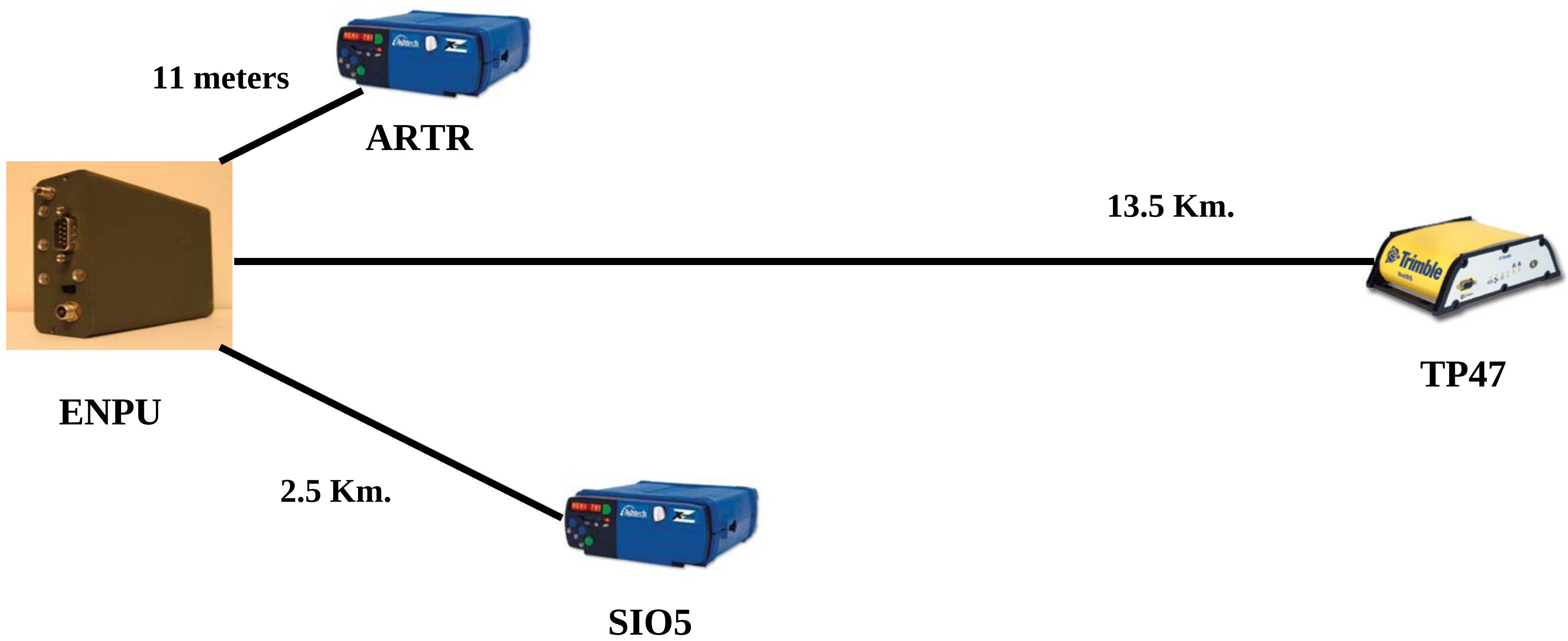
ENPU Accuracy Testing



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ENPU Accuracy Testing (cont.)

Outdoor Environment – Open Sky

Indoor Environment

Note: Testing for GPS only capabilities i.e. no IMU, no smoothing etc.

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ENPU Accuracy Testing (cont.)

STAND-ALONE PERFORMANCE

NPU Outdoor Performance		**Note: All values are in meters**				
	Test Date	**North StdDev**	**East StdDev**	**Up StdDev**		
	4/30/2006	4.55727	3.30303	9.56708		86399 solutions with 1511 outliers (1.7%) (0 non-solutions)
NPU Indoor Performance		**Note: All values are in meters**				
	Test Date	**North StdDev**	**East StdDev**	**Up StdDev**		
	5/29/2006	6.92149	4.53512	14.18528		84961 solutions with 1101 outliers (1.3%) (65 non-solutions)

DIFFERENTIAL PERFORMANCE

NPU Outdoor Performance		**Note: All values are in meters**					
	Test Date	**Reference**	**Baseline**	**North StdDev**	**East StdDev**	**Up StdDev**	**Solutions**
	4/30/2006	ARTR	11.08218	0.6937	0.59169	1.79606	86362 solutions with 117 outliers (0.1%) (37 non-solutions)
1	4/30/2006	SIO5	2514.32131	0.64314	0.56589	1.55919	86399 solutions with 113 outliers (0.1%) (0 non-solutions)
	4/30/2006	P472	13538.93553	0.67077	0.58248	1.62057	86399 solutions with 130 outliers (0.2%) (0 non-solutions)
NPU Indoor Performance		**Note: All values are in meters**					
	Test Date	**Reference**	**Baseline**	**North StdDev**	**East StdDev**	**Up StdDev**	**Solutions**
	5/29/2006	ARTR	10.92737	3.45577	2.8116	7.13446	83560 solutions with 1056 outliers (1.3%) (2839 non-solutions)
2	5/29/2006	SIO5	2514.92052	3.42554	2.79797	7.0174	83897 solutions with 1082 outliers (1.3%) (2502 non-solutions)
	5/29/2006	P472	13537.00244	3.41271	2.80889	7.06108	83846 solutions with 1017 outliers (1.2%) (2553 non-solutions)

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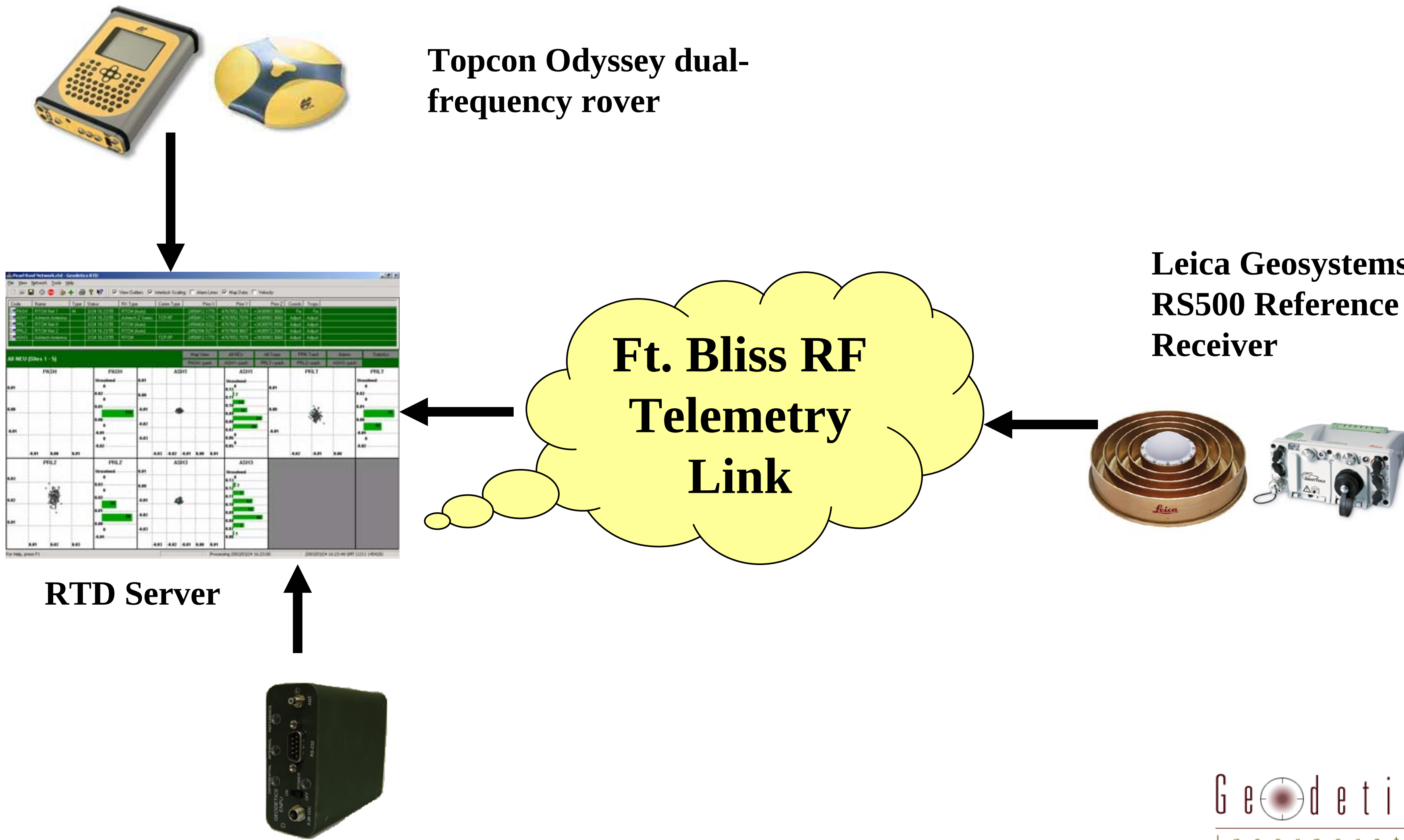
ENPU Accuracy Testing at Ft. Bliss for FCS Testing



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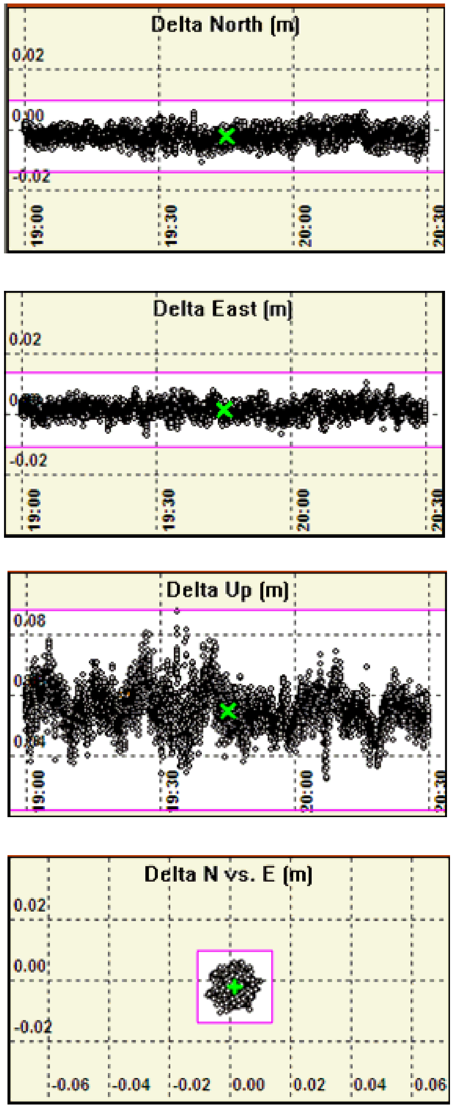
ENPU Accuracy Testing at Ft. Bliss

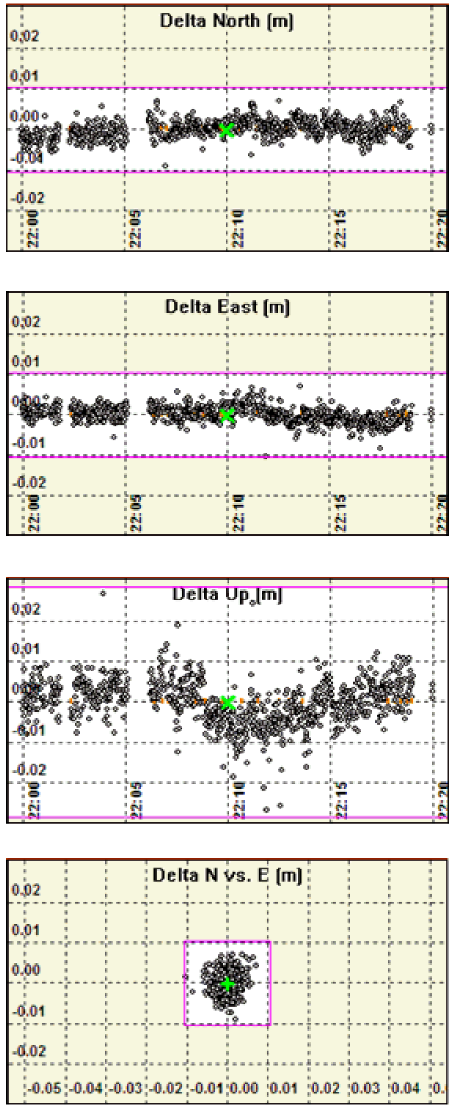
Ft. Bliss Test Site

ENPU Accuracy Testing at Ft. Bliss

Test 1: Topcon at "L10"



Test 4: Topcon at "L9"



Test 1: Topcon at "L10"

	North (meters)	East (meters)	Up (meters)
IQR	0.003	0.003	0.009

Test 4: Topcon at "L9"

	North (meters)	East (meters)	Up (meters)
IQR	0.003	0.003	0.0072

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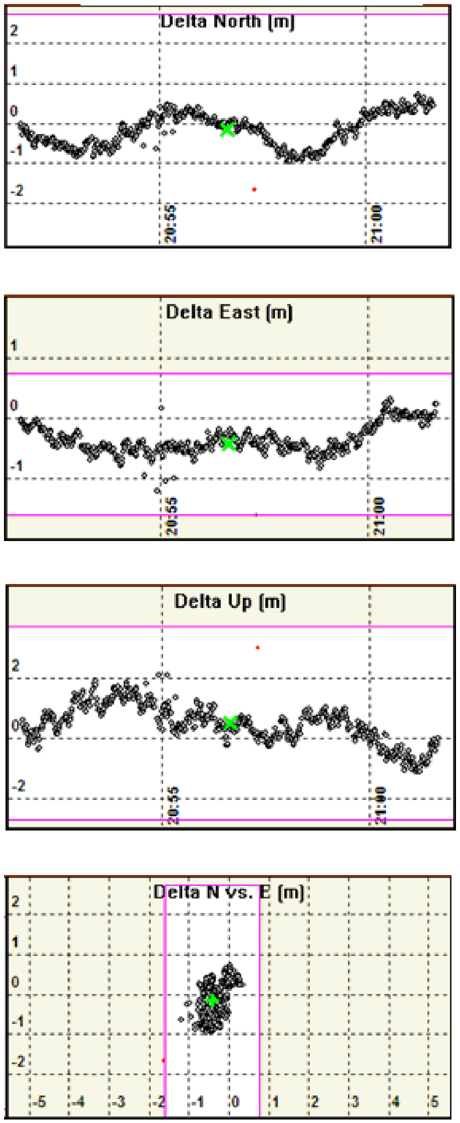
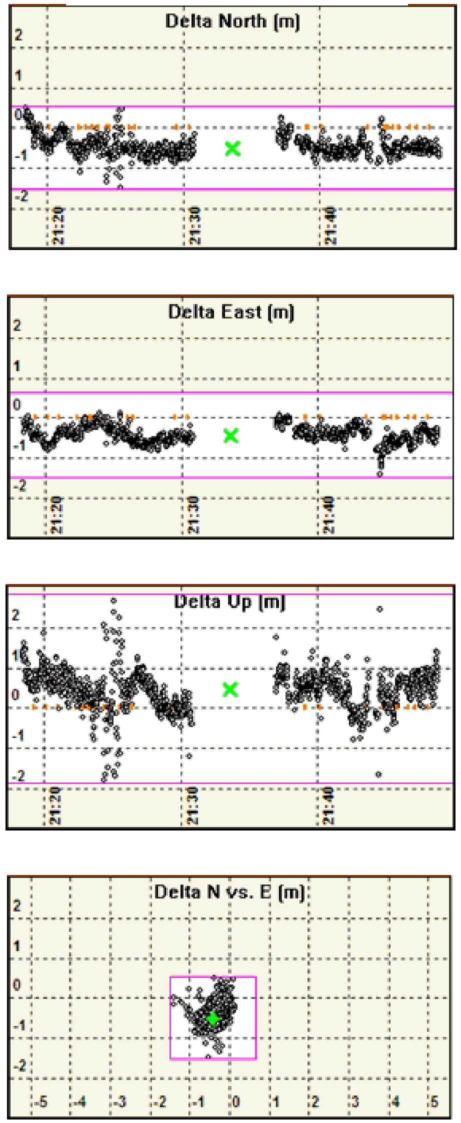
ENPU Accuracy Testing at Ft. Bliss

Test 2: SiRF at "L10"



Test 3: SiRF at "L9"



Test 2: SiRF at "L10"

	North (meters)	East (meters)	Up (meters)
Mean Diff.	-0.153	-0.405	0.450
IQR	0.730	0.294	0.802

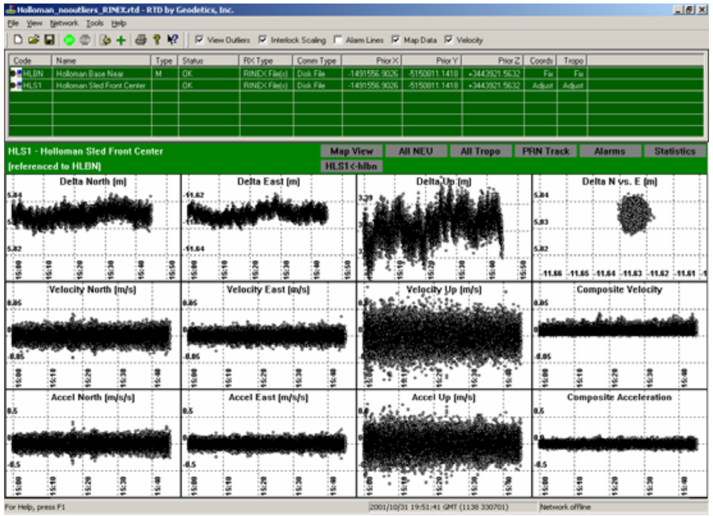
Test 3: SiRF at "L9"

	North (meters)	East (meters)	Up (meters)
Mean Diff.	-0.487	-0.425	0.467
IQR	0.260	0.268	0.587

Geodetics Incorporated

Epoch-by-Epoch™ Test Verification

- Geodetics technologies were extensively tested by DoD and are making their way into many projects in the Military
- The Central Test & Evaluation Investment Program (CTEIP) has funded a program to evaluate the performance of Epoch-by-Epoch™ (EBE) technology for test and evaluation instrumentation applications.
- EBE technology has undergone extensive testing in both live and simulated tests under strenuous environments, including:
    - Low Dynamics
    - High Dynamics
    - SAASM under High Dynamics
    - Attitude Determination



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ITEA Award

The preceding tests results were published in the October 2004 International Test and Evaluation Association Journal under the title:

"Epoch-by-EpochTM Real-Time GPS Positioning in High Dynamics and at Extended Ranges“

The paper was selected by the ITEA publications committee as the most important paper published in 2004.

Geodetics, together with its co-authors received the award at the annual ITEA International Symposium in September 2005

Geodetics
Incorporated

Nunn-Perry Award

Geodetics and Lockheed Martin entered a three year DOD sponsored Mentor-Protégé (MP) agreement in August, 2005. The program was awarded by the OSD Office of Small Business Utilization through the U.S. Navy SPAWAR, San Diego, CA, Joint Robotics Program (JRP).

Under this program Lockheed Martin is mentoring Geodetics, in the manufacture of high-accuracy, real-time geo-location sensor systems based on GPS technology. This MP agreement enables Geodetics to deliver turn-key hardware/software solutions to the Government.

This year, the Geodetics/Lockheed Martin Team was selected as the top Mentor-Protégé team out of several hundred such DOD M/P teams.

The Geodetics/Lockheed Martin Team will receive the prestigious Nunn-Perry award in March recognizing the team as the best in the DOD.

Geodetics
Incorporated

Ship Suitability Test and Evaluation – Preparing for the Future

Presented by Steven L. Fischer, Head ATC and Landing Systems
and Colin Burns, Head Rotary Wing Ship Suitability
Naval Air Warfare Center, Patuxent River, MD
14 March 2007

Overview

- Ship Integration Considerations
- Ship Suitability Test and Evaluation
- Aircraft Programs
- Ship Programs
- UAV / UCAV Programs
- T&E Tools
- Ship Suitability Unique Challenges
- Summary

Ship Integration Considerations

Design Considerations

- **All major aircraft design considerations are driven by requirement to operate on a ship**
  - Wingspan / rotor span
  - Aircraft length and height
  - Control surface sizing and flight control system
  - Landing gear
  - Cockpit design
  - Weapons carriage locations
  - Servicing/Maintenance interfaces
  - Support equipment
  - Materials (corrosion / fire)

Environmental Considerations

- **Adverse operating environment**
  - Ship's Motion
  - Ship's Airwake
  - Confined Area
  - Corrosive Hazards
  - Acoustic Hazards
  - Ingestion Hazards
  - Electromagnetic Hazards

Ship Suitability Test and Evaluation

- **Provides the engineering people, processes, and facilities to conduct tests to determine air vehicle compatibility with the shipboard operating environment to include**
  - Launch and Recovery Equipment
  - Air Traffic Control and Landing Systems
  - Shipboard facilities

- **Located at the Naval Air Warfare Center, Patuxent River, MD**
- **Three Branches within the Integrated Systems Evaluation, Experimentation, and Test Department**
  - Fixed Wing
  - Rotary Wing
  - Air Traffic Control and Landing Systems

- **Work closely with all engineering and logistics competencies and other countries**

Fixed Wing
Ship Suitability T&E

- **Charter**
  - Determine the performance and compatibility of manned and unmanned conventional and V/STOL aircraft, and aircraft systems in the shipboard operating environment for all classes of aircraft carriers, amphibious ships, and from advanced airfields
- **Primary areas of T&E expertise**
  - Aircraft low airspeed flying qualities and performance
  - Launch and recovery structural suitability
  - Aviation facility requirements
  - Launch and recovery envelope development

Shake, Rattle, and Roll

Cleared for Public Release

Rotary Wing
Ship Suitability T&E

- **Charter**
  - Determine the performance and compatibility of manned and unmanned rotorcraft, and rotorcraft systems in the shipboard operating environment for all classes of aircraft carriers, amphibious ships, aviation capable ships
- **Primary areas of T&E expertise**
  - Rotorcraft flying qualities and performance
  - Aviation facility requirements
  - Launch and recovery envelope development (Dynamic Interface)

DI Testing

- Over 20 different ship classes



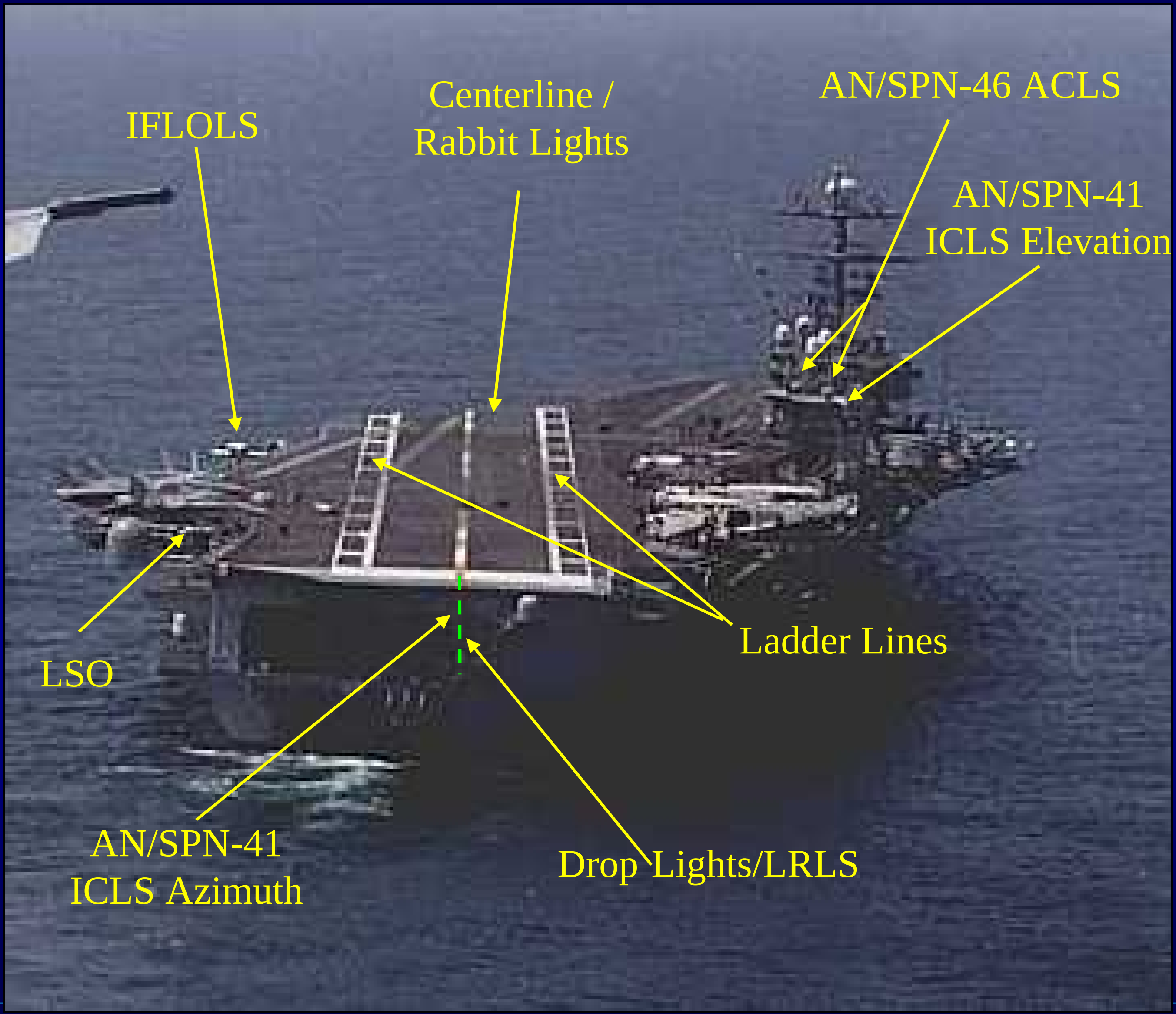
- Over 15 different helicopter types



Air Traffic Control and Landing Systems T&E

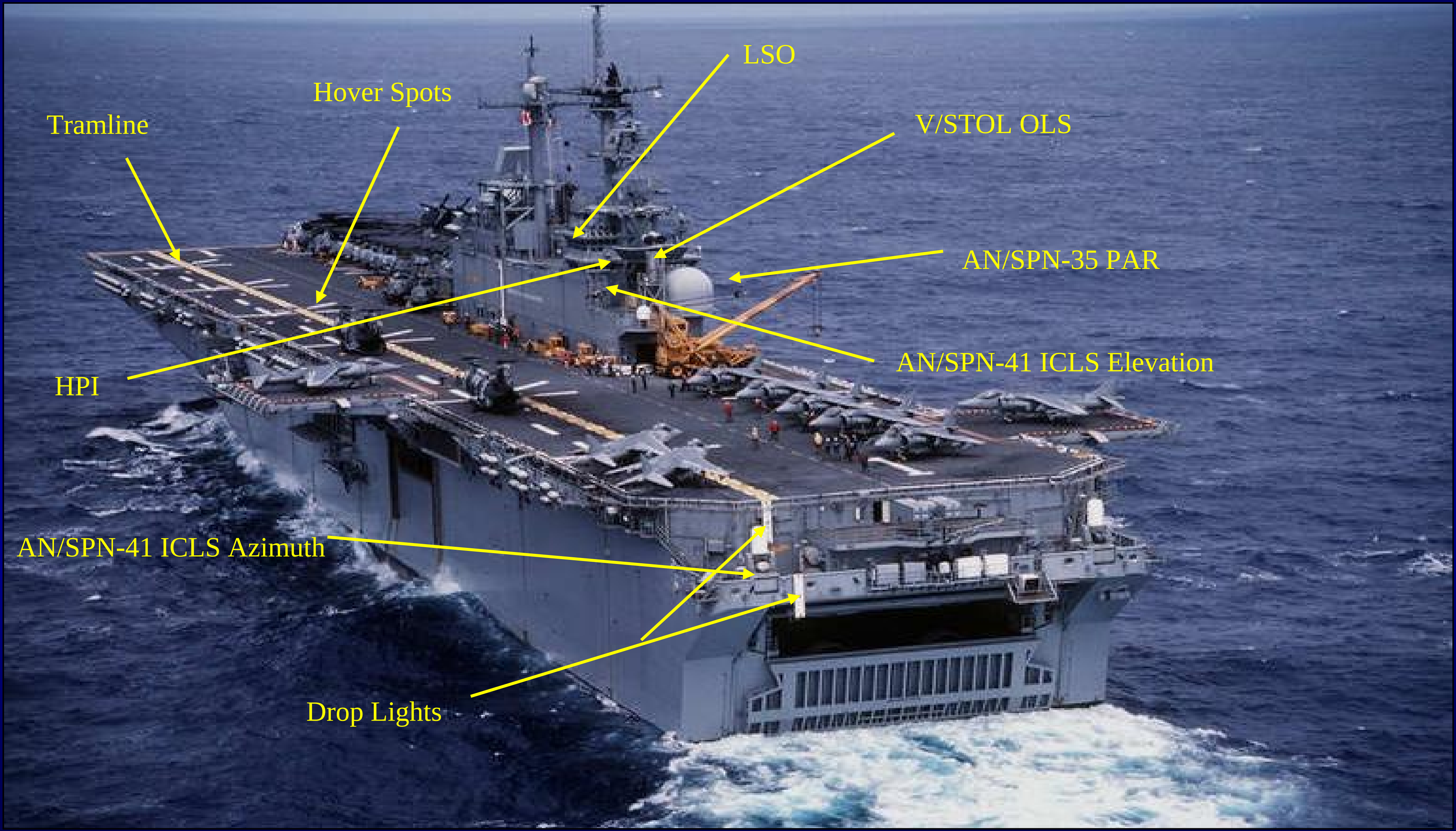
- **Charter**
  - Develop, test, and evaluate shipboard, shore based, and satellite-based Air Traffic Control and Landing Systems (ATC&LS) and related aircraft avionics systems for manned and unmanned air vehicles
- **Primary areas of T&E expertise**
  - Precision Approach and Landings Systems (PALS)
  - Visual landing aids
  - Aircraft landings aids
    - **Auto Throttle Systems**
    - **Auto Pilot Systems**
    - **Displays**

Aircraft Carrier Landing Aids



PALS Approach

Amphibious Assault Ship Landing Aids



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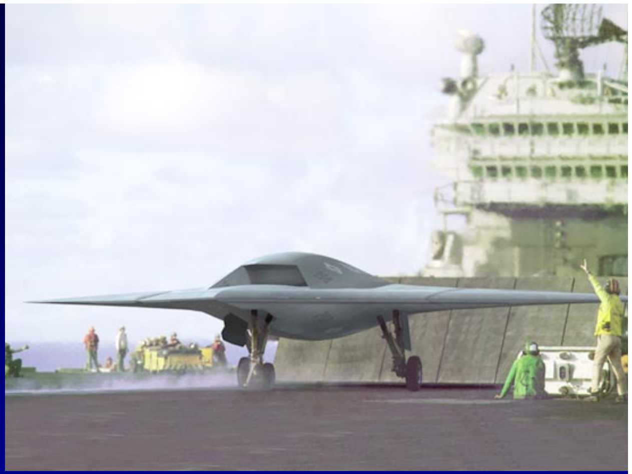


Aviation Programs

Rotary Wing Aviation Programs

MV-22

UH-1Y and AH-1Z Upgrades

MH-60R/S

Presidential Helicopter Program

Heavy Lift Helicopter Program

V-22

- **Shore based and shipboard developmental test requirements are complete**
- **Further testing required**
  - Increase launch and recovery wind envelopes for all classes of ships
  - Software regression testing

UH-1Y / AH-1Z

- Major upgrades to the UH-1 Huey and AH-1 Cobra
  - New four bladed main rotor / Increased engine power
  - Increased gross weight
  - New cockpit
  - Survivability upgrades
  - Significant increase in commonality between UH-1 and AH-1

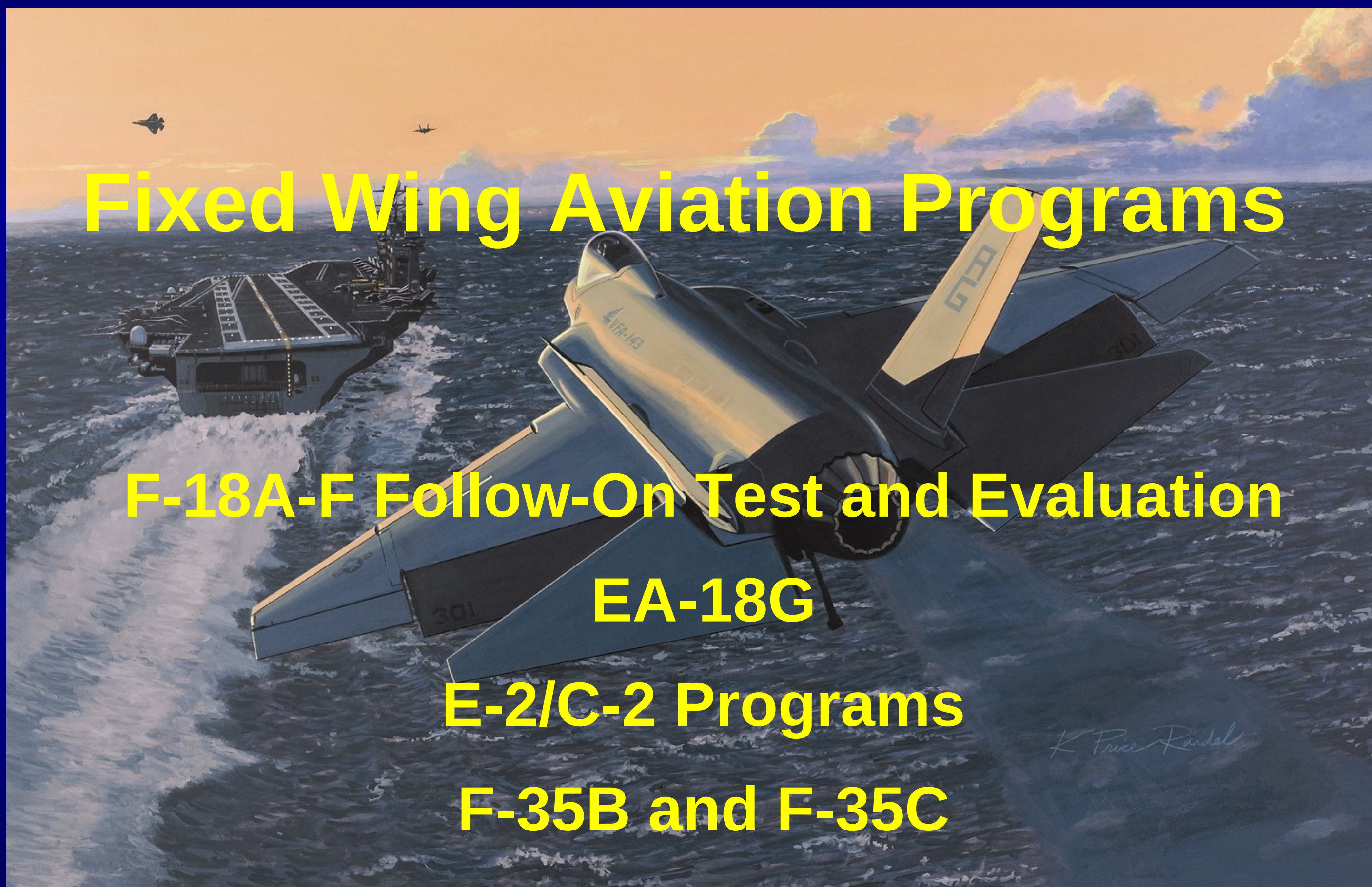
- Test program
  - Shore based and shipboard developmental test requirements are complete, DI tests in 2005
  - Further testing required
    - Increase launch and recovery wind envelopes for all classes of ships
    - Cockpit integration

MH-60R/S

- **The MH-60R/S programs are upgrade programs that will provide capability improvements to U.S. Navy SH-60 series helicopters and introduce new capability**
  - Mission areas for the MH-60R
    - **Undersea Warfare, Anti-Surface Warfare, Area Surveillance and Combat Identification, Naval Surface Fire Support, Search and Rescue**
  - Mission areas for the MH-60S
    - **Vertical Replenishment, Amphibious Search and Rescue, Vertical Onboard Delivery, Airborne Mine Countermeasures, Combat Search and Rescue**
- **DI testing**
  - MH-60R: Essentially complete
  - MH-60S: On-going

VH-71/CH-53K

- **VH-71 Presidential Helicopter will have shipboard operating capability**
  - DI testing planned in 2009
- **CH-53K Heavy Lift Helicopter**
  - Replaces the CH-53E, improved lift capability / R&M
  - DI testing in 2011/2012 timeframe



Fixed Wing Aviation Programs

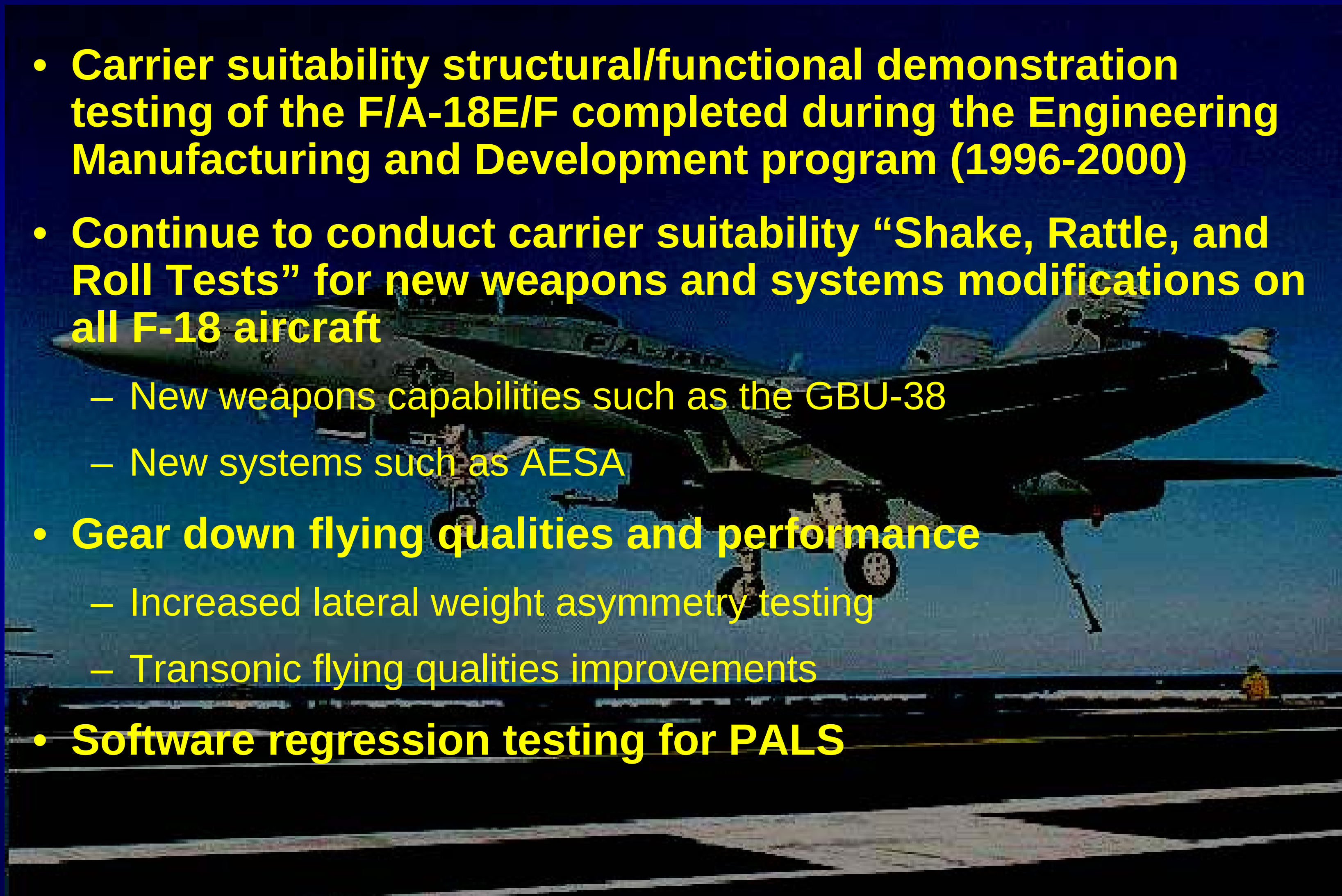
F-18A-F Follow-On Test and Evaluation

EA-18G

E-2/C-2 Programs

F-35B and F-35C

F/A-18A-F



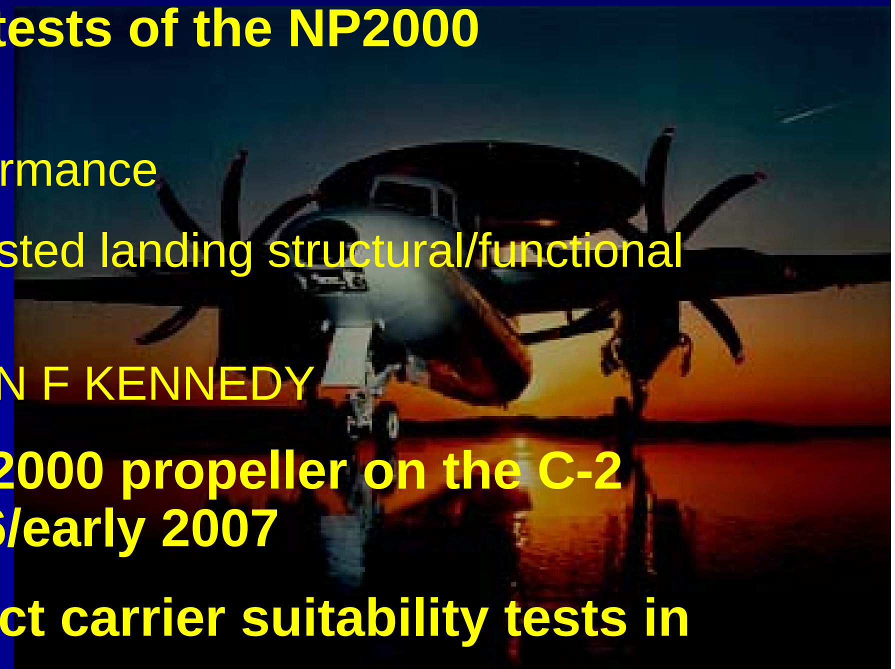
- **Carrier suitability structural/functional demonstration testing of the F/A-18E/F completed during the Engineering Manufacturing and Development program (1996-2000)**
- **Continue to conduct carrier suitability “Shake, Rattle, and Roll Tests” for new weapons and systems modifications on all F-18 aircraft**
  - New weapons capabilities such as the GBU-38
  - New systems such as AESA
- **Gear down flying qualities and performance**
  - Increased lateral weight asymmetry testing
  - Transonic flying qualities improvements
- **Software regression testing for PALS**

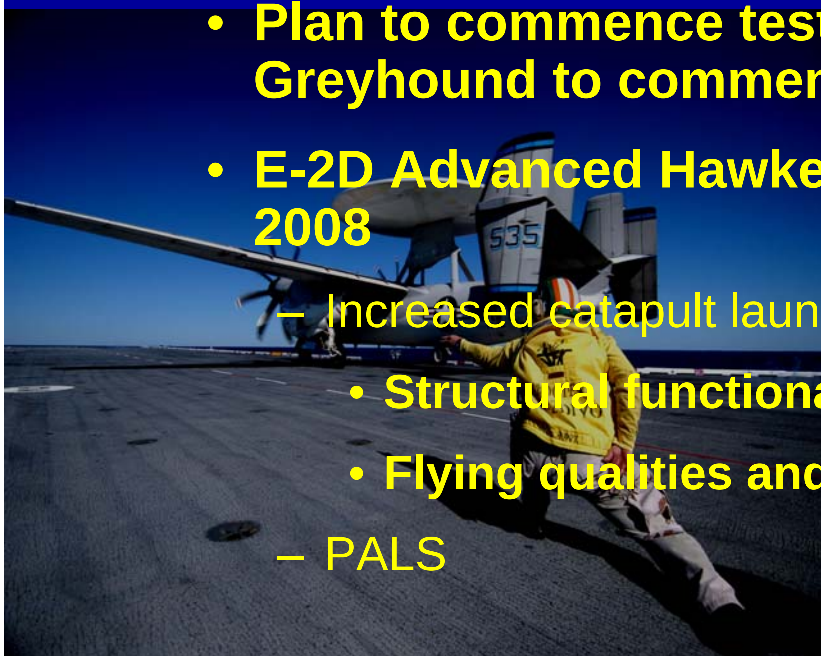
NAVAIR

EA-18G

- **EA-18G will replace the EA-6B**
- **Air vehicle testing underway with F/A-18E/F aircraft**
- **Carrier suitability test requirements**
  - Flying qualities and performance
    - **New external load configuration**
  - Catapult launch and arrested landing structural demonstration of aircraft modifications and external pods
    - **Includes increased gross weight for carrier landings**
    - **Also expanding lateral asymmetry capability for all F/A-18E/F/G aircraft**
  - PALS testing

E-2 Hawkeye / C-2 Greyhound





- **Very successful carrier suitability tests of the NP2000 propeller on the E-2 Hawkeye**
  - Shore based flying qualities and performance
  - Shore based catapult launch and arrested landing structural/functional demonstration
  - Shipboard tests aboard the USS JOHN F KENNEDY
- **Plan to commence testing the NP-2000 propeller on the C-2 Greyhound to commence late 2006/early 2007**
- **E-2D Advanced Hawkeye to conduct carrier suitability tests in 2008**
  - Increased catapult launch and arrested landing gross weight
    - **Structural functional tests**
    - **Flying qualities and performance**
  - PALS

Joint Strike Fighter

- **Tests with F-35B STOVL and F-35C Carrier variants**
  - F-35B testing scheduled to commence in 2008
    - **First all-new STOVL tactical jet aircraft designed for U.S. operational use**
    - **Ski jump tests**
    - **First at-sea testing in 2010**
  - F-35C testing scheduled to commence in 2009
    - **Last of three variants to enter testing**
    - **Least common of the three variants**
    - **At-Sea testing in 2010**

Air Traffic Control and Landing Systems Programs

Aircraft Carrier and Amphibious Assault Ship PALS Certification

Joint Precision Approach Landing System (JPALS)

MV-22

UCARS

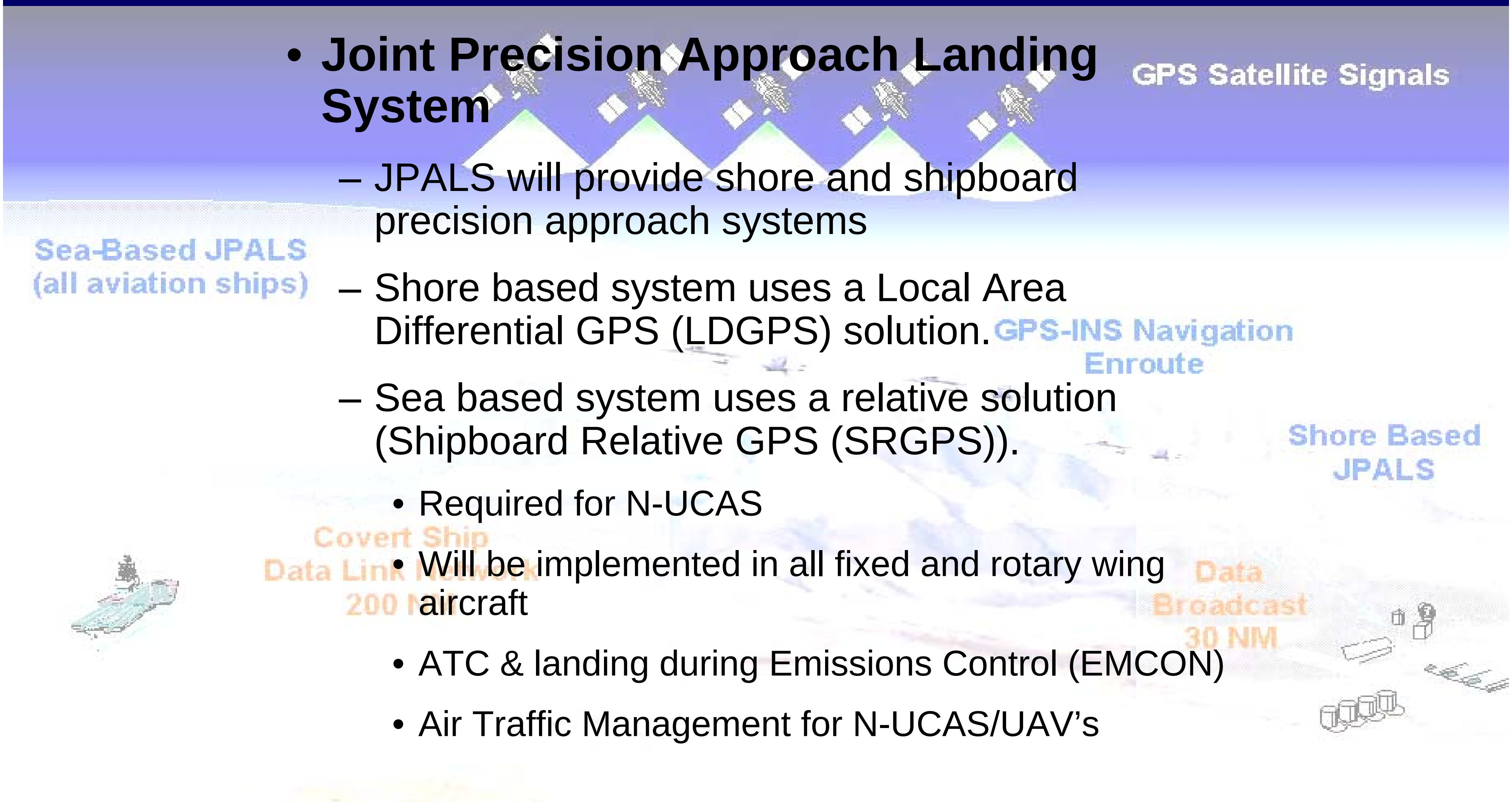
PALS Certification

- **SPN-46 Automatic Carrier Landing System (ACLS)**
  - All CV/CVN ships
    - Includes “hands-off” automatic landing
- **SPN-41 Instrument Control Landing System (ICLS)**
  - CV/CVN and LHA/LHD ships
    - Provides “needles” indication
- **AN/SPN-35 Precision Approach Radar**
  - LHA/LHD ships
    - Provides ship-based controller “talk down” approach capability to all aircraft

Cleared for Public Release

JPALS

- **Joint Precision Approach Landing System**
  - JPALS will provide shore and shipboard precision approach systems
  - Shore based system uses a Local Area Differential GPS (LDGPS) solution.
  - Sea based system uses a relative solution (Shipboard Relative GPS (SRGPS)).
    - Required for N-UCAS
    - Will be implemented in all fixed and rotary wing aircraft
    - ATC & landing during Emissions Control (EMCON)
    - Air Traffic Management for N-UCAS/UAV's



NAVAIR

MV-22

- **Shore based developmental and certification test flights have been completed, or are in process on the following Uncoupled and Coupled Flight Director and Autopilot modes:**
  - Approach to hover
  - Coupled hover
  - Waypoint mode
  - Instrument Landing System
  - TACAN

UCARS/VTUAV

- **The Unmanned Common Automatic Recovery System is being used with the Fire Scout VTUAV for Launch and Recovery**

  – UCARS will be incorporated in LCS for VTUAV Launch and Recovery

  – Functions similarly to the AN/SPN-46 ACLS


Ship Programs

LPD 17
Landing Platform Dock

- **Strategic for "Forward from the Sea"**
- **Designed to transport the latest Marine Corps hardware – called the Mobility Triad**
  - Advanced Amphibious Assault Vehicles (AAAV)
  - Landing Craft Air-Cushioned (LCAC)
  - MV-22 Osprey
- **LPD 17 testing commenced in 2006**
  - All Navy/Marine ship-capable helicopters (including V-22)
  - AV-8B Harrier tests in 2007

Littoral Combat Ship

- **Flagship for Naval transformation**
  – Shift from blue water to littoral operations
  – High speed capability / Long range
  – Missionized modules for
    - **Mine warfare**
    - **Anti-submarine warfare**
    - **Anti-surface warfare**

Lockheed Design

General Dynamics Design

– Designed for manned and unmanned aircraft operations
  - **MH-60R/S**
  - **VTUAV**

– Each contractor to build two ships
  - **DI testing of first ship in 2008**

NAVAIR

DDG 1000

- **Revolutionary Design**
  - Initial Fleet capability in 2013
  - Two helicopter landing spots
    - **MH-60R**
    - **UAV's**

USS George H. W. Bush
CVN-77

- **10'th and final Nimitz Class carrier**
- **Similar to USS Ronald Reagan, CVN-76**
  - Island shifted aft
  - Three arresting gear wires
- **Enters service in 2009**
- **Modernized island**
- **New radar tower**

CVN 21

- New design
- Optimized flight deck for air operations
- Decreased manpower
- Electromagnetic Aircraft Launch System (EMALS)
- Advanced Arresting Gear (AAG)

Cleared for Public Release


UAV and UCAS Programs

Small UAV's

RQ-8A/B Fire Scout

X-45 / X-47 N-UCAS

Small UAV's

- **Many different UAV's with many different launch and recovery concepts**

  – Fixed Wing UAV's
    - **Pneumatic and bungee powered launchers**
    - **Net, vertical cable, and horizontal cable arrestment systems**
  – Helicopters
    - **Harpoon type system for launch and recovery**
  – Types of control stations
    - **Integrated / stand-alone**
  – Vehicle control methods for launch and recovery
    - **Manual**
    - **Automatic**

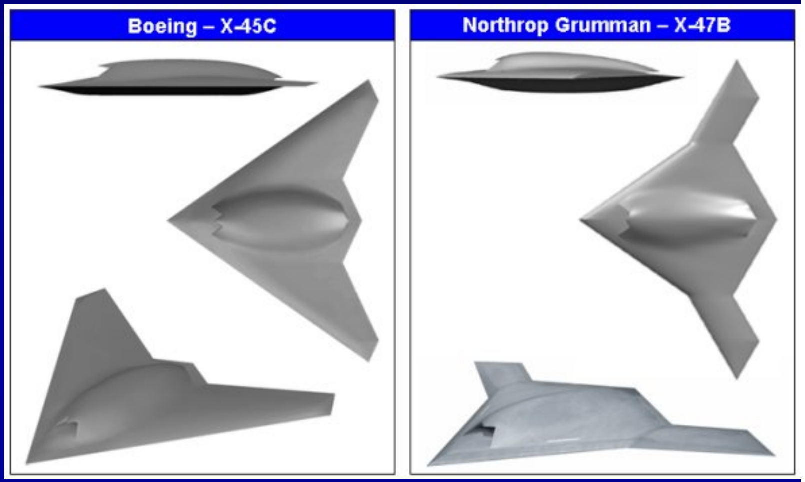
Why We Test UAV's

RQ-8A/B Fire Scout

- **Vertical Takeoff Unmanned Air Vehicle for the Navy**
  - Design based on a Schweitzer 330 commercial manned helicopter
  - RQ-8A missions include Reconnaissance, Surveillance, and Target Acquisition
  - RQ-8B to add increased payload and weapons capability
- **Autonomous Takeoff and Landing capability (ship and shore)**
- **Successful shipboard demo in Jan 2006 aboard the USS Nashville (LPD-13)**

N-UCAS

- **Biggest challenge for ship suitability T&E**
  - F/A-18 sized aircraft with weapons capability
  - Long range / persistence
  - Deployed on aircraft carriers
    - **Catapult launch and arrested landing capability**
  - Autonomous launch and recovery
    - **Must be integrated into normal shipboard operations**
      - Deck operations
      - Integrated into the Carrier Air Traffic Control Center



- **Shore based and shipboard carrier demo in 2009**

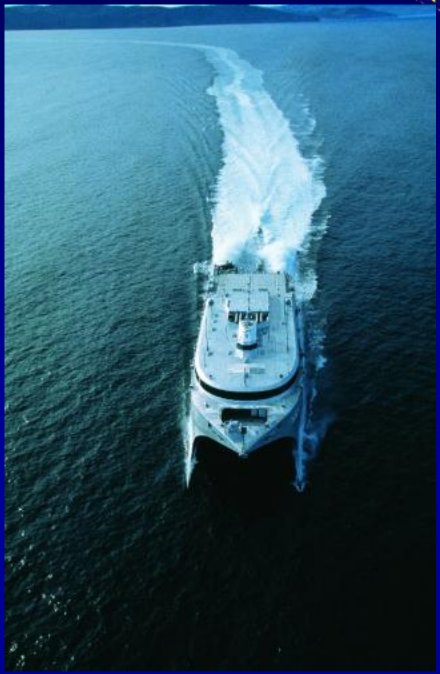
Ship Suitability
T&E Tools

Demonstrators

Modeling and Simulation

Demonstrators

Demonstrators – HSV / X-Craft



- **Used to develop concept of operations for the Littoral Combat Ship**
- **DI tests conducted on both HSV-1 and HSV-2**

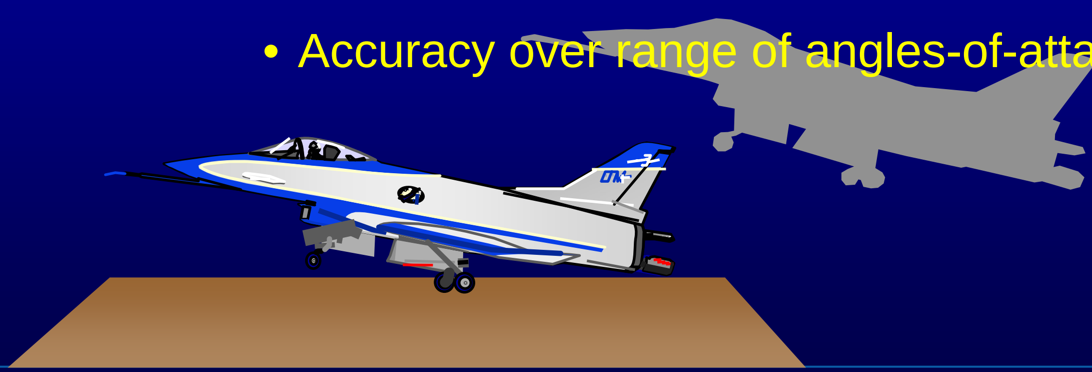
- **Littoral Surface Craft – Experimental (also known as the X-Craft) christened in February 2005 as USS Sea Fighter**
  - DI tests conducted in December 2005

X-35 Concept Demonstrators

- **This JSF "X" program was not a fly-off**
- **The demonstrators were used to**
  - Reduce risk in critical areas
    - **STOVL lift system design**
    - **Surface erosion**
    - **Manufacturing techniques**
- **Demonstrate modeling and simulation capability**
  - Vehicle performance prediction

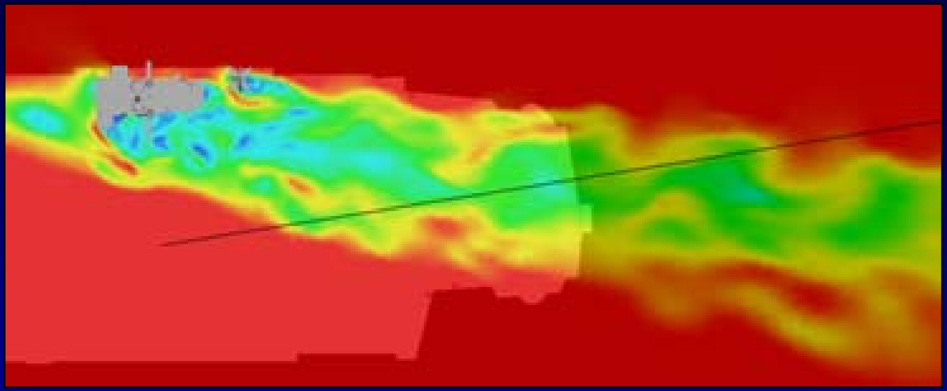
X-31 VECTOR

- **VECTOR - Vectoring ESTOL Control Tail-less Operation Research**
  - Tests conducted using the X-31 to evaluate capability to fly approaches at very high angles-of-attack to demonstrate extremely short takeoff and landing technology
    - Requires fully automated landing system
    - Integrated advanced high integrity, highly precise navigation system
    - Use of thrust vectoring for lateral-directional control
  - Evaluated advanced Flush Air Data System
    - Redundancy
    - Accuracy over range of angles-of-attack



Demonstrators – Surrogate Testing

- **Often used surrogate vehicles to reduce the cost of testing and complete preliminary evaluations of new technologies**
  - Small twin engine commercial aircraft for PALS and JPALS testing
  - VAAC Harrier used for JSF STOVL
    - **Control law development and demonstration**
    - **Autoland development and demonstration**



Modeling and Simulation (M&S)

General

Wind Tunnel

CFD

Displays

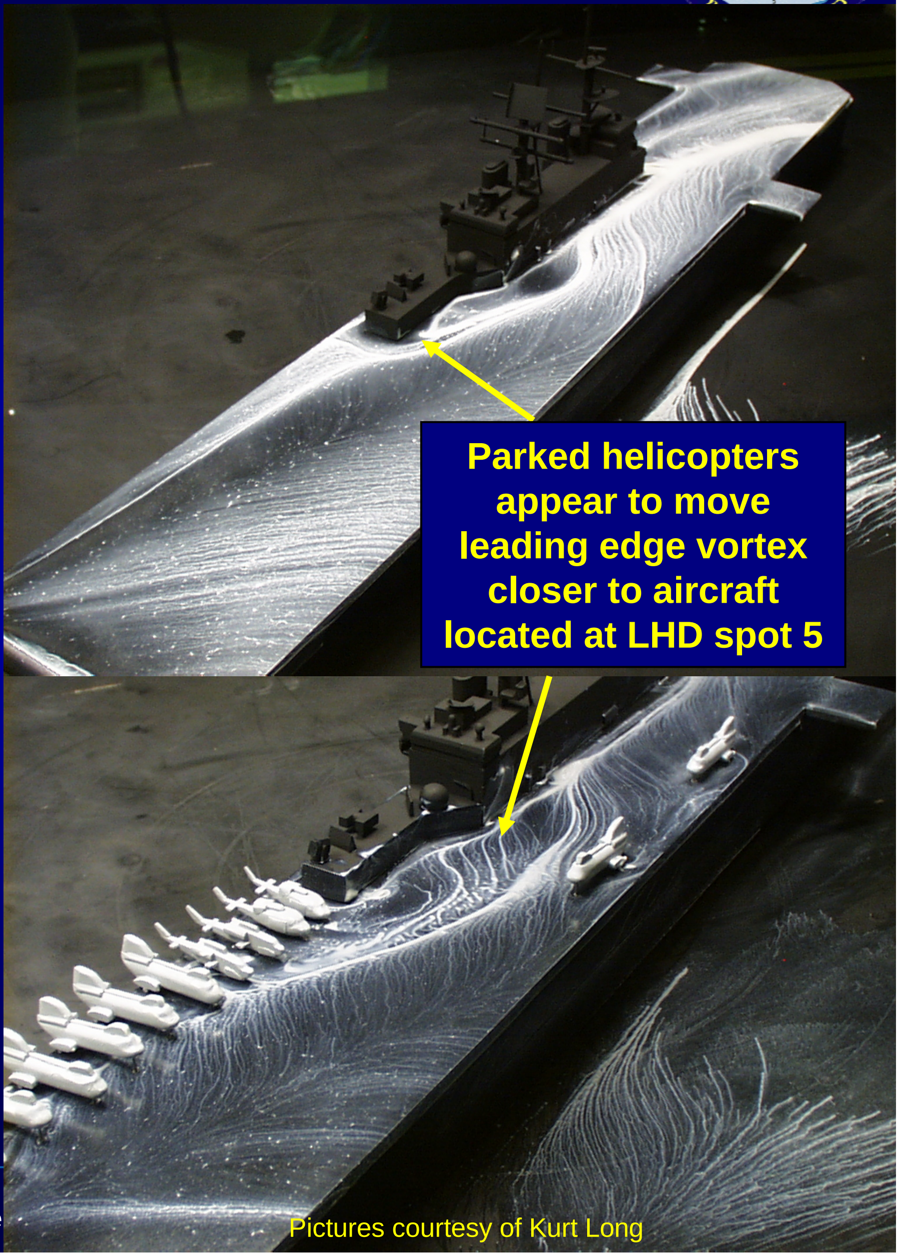
Other Initiatives

M&S – General

- **Historical improvements**
  - Catapult minimum endspeed predictions
  - Approach airspeed evaluations
  - Degraded flight control modes and emergency configurations
- **F-35 control law development**
- **PALS**
  - Aircraft auto-pilot and auto-throttle control law development
  - Ship/Shore based ACLS system control law development

M&S – Wind Tunnel

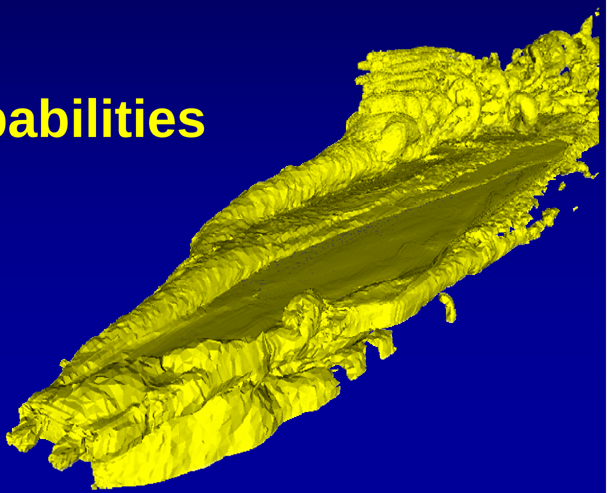
- **Measure ship's airwake**
  - Investigate effects of ship's topside configuration
  - Used to develop and confirm Computational Fluid Dynamics predictions
- **Ship's anemometers**
  - Determine optimum location
  - Develop source error corrections for Fleet use
- **Effects of aircraft parked on the flight deck**

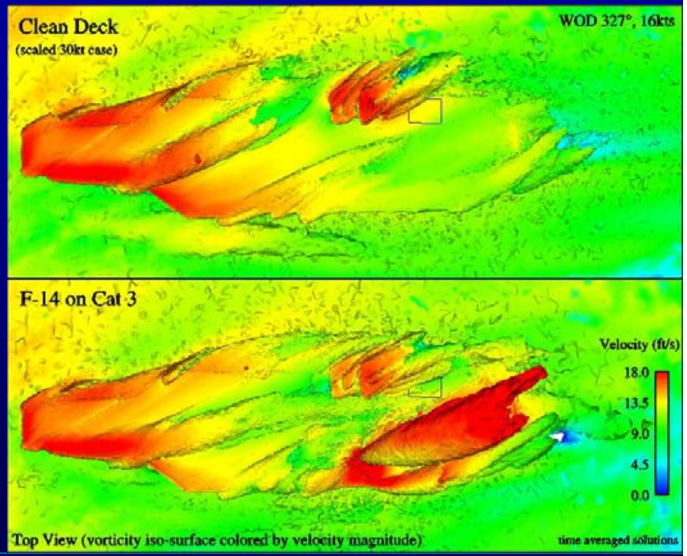


Pictures courtesy of Kurt Long

M&S –
Computational Fluid Dynamics

- **Utilizing NAVAIR Advanced Aero expertise and capabilities**
- **Ship's airwake predictions**
  - Aerodynamic effect of deck and island geometry
  - Fixed wing aero performance and handling qualities investigations
  - Validation for CVN-21
- **Predict aircraft interaction**
  - JSF engine outwash
- **Analysis of fixed wing / rotary wing interactions**
  - F-14 engine exhaust velocities on helicopter operating in a new landing spot aft of the island

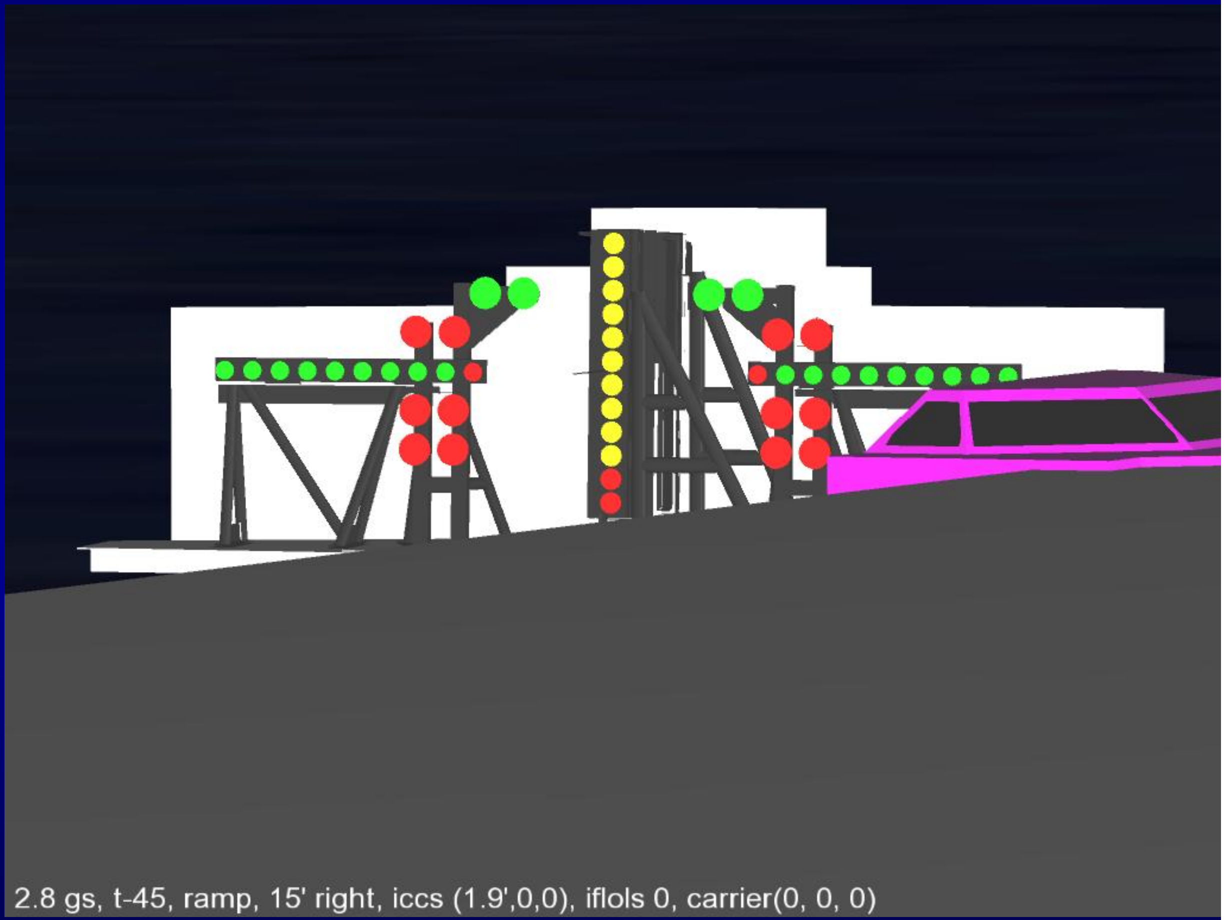




Pictures courtesy of Susan Polsky

M&S - Visual Displays

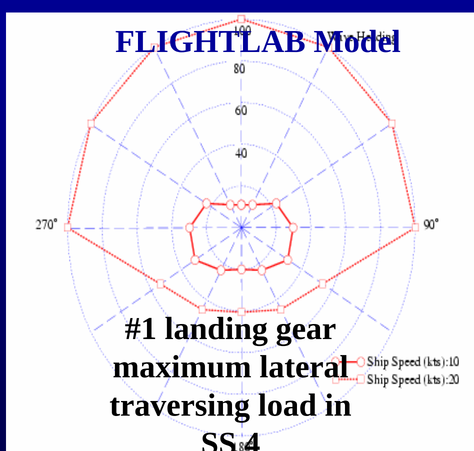
- Evaluation of new visual landing aids
- Evaluation of ship's topside layouts
- Utilize NAVAIR Human Factors expertise



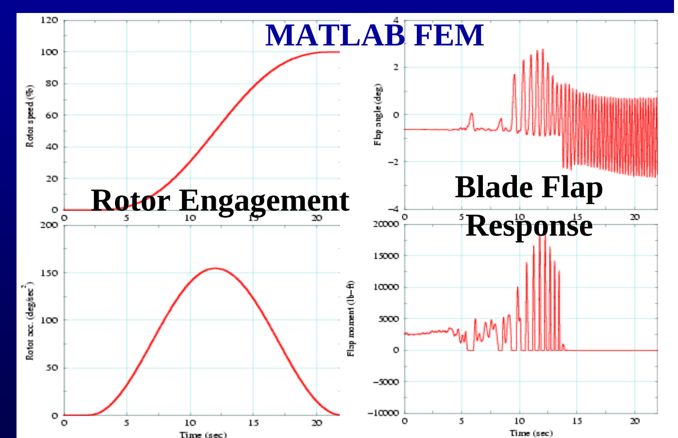
NAVAIR

M&S –
Other Initiatives

- **In-Work Items**
  - Enhanced rotorcraft aerodynamics models that focus on dynamic stall, rotor tip design, high rate of descent and downwash
  - Helicopter rotor engage/disengage model
  - PC-based visual landing aid (VLA) test tool
  - Helicopter deck traversing and securing analysis tool



Pictures courtesy of Dean Carico



Unique Challenges

UAV / UCAS

Data Collection and Analysis

Fleet/Program Response

Test Techniques

UAV/UCAS Challenges

- **Performance specifications**
- **Innovative Launch and Recovery techniques**
- **Myth of the expendable air vehicle**
- **Test unique procedures**
  – Test unique flight profiles
  – Replicating the Carrier Controlled Approach (CCA) environment
  – Shipboard testing

Data Collection and Analysis

- **Constraints during shipboard testing**
  - Real estate / situational awareness issues
  - Requirement for quick turnaround of data
- **JPALS data collection challenge**
- **F-35 data quantity challenge**
- **Data analysis tools in development**
  - Intelligent aircraft/ship data analysis options to help support future aircraft/ship testing and related database requirements
  - Analytic capability to support multi-aircraft/ship testing and related analysis

Cleared for Public Release

Response Challenges

- **Quick response test requirements to provide immediate capability based on emerging Fleet requirements or technical issues**
- **Within last year, we have deployed teams to:**
  - Carrier operating in WESTPAC (PALS support)
  - Carrier operating in Persian Gulf (PALS support)
  - Command and Control ship operating off of Korea (DI)
  - Scan Eagle emerging requirements on four ship types (DI)
- **These “pop-up”, immediate support requirements stretch staffing requirements**

Test Techniques – Learning from the Past

- **C-130 deck launch / AV-8B STOVL / Conventional Ski Jump**
  - Reviewing tests conducted decades ago to glean information
  - Not all testing feasible in today's environment of Operational Risk Management

USS FORRESTAL (CVA 59)

Test Techniques – New Technology Areas

- **On-aircraft test aids**
  - Increased capability while testing on ships
  - Dial-a-Function
  - Net capable TM
- **Creating new techniques**
  - JPALS data collection
  - UAV test requirements and techniques
    - **N-UCAS**
    - **Small UAV's**

Summary

- **Large number of aircraft and ship test programs facing the ship suitability T&E group**
- **Must be able to support these programs with less manpower**
  - **Test team versatility**
  - **Increased dependency on M&S**
  - **Better data analysis tools**
- **Must learn from past programs**
  - **C-130**
  - **AV-8B STOVL**
  - **Conventional Ski-Jump**
- **Develop new and innovative test techniques**
  - **JPALS**
  - **N-UCAS**


JUST ANOTHER
DAY AT THE OFFICE
Questions

Video

Cleared for Public Release

LMI
GOVERNMENT CONSULTING
THE OPPORTUNITY TO MAKE A DIFFERENCE HAS NEVER BEEN GREATER

Understanding The Combined Influence On Ownership Cost Of Reliability, Maintainability, Component Packaging, Commonality, and Support Process Performance

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Ver. 3c3

ACQUISITION • FACILITIES & ASSET MANAGEMENT • FINANCIAL MANAGEMENT • INFORMATION & TECHNOLOGY • LOGISTICS • ORGANIZATIONS & HUMAN CAPITAL

Background

- Importance of reliability to ownership cost has been studied and documented for many years*
- Other aspects such as maintainability, commonality, component packaging, and cycle time also studied, although less frequently*
- Each studied more or less in isolation
- Not as well understood is the relative and combined importance of five dimensions
  - Reliability
  - Maintainability
  - Component packaging, e.g. choice of line replaceable modules (LRMs) versus Line Replaceable Units (LRUs)
  - Commonality, and
  - Performance of the support process

*References on slide 17

Purpose of Presentation

- Using data representative of a complex ground platform electronics subsystem, examine the relative importance of the five dimensions from the perspective of ownership cost
- Show how plausible improvement in a dimension, or combination of dimensions, affects ownership cost
- By characterizing what amounts to a trade space analysis can help inform the allocation of constrained test and evaluation resources

Data

- **System**: high technology electronics used on mobile ground platforms, with two types of LRUs
  - LRU A: $81K each, 5 per system, mean time between failure (MTBF) = 4,000 hours; comprising 7 types of SRUs;
  - LRU B: $70K each, 2 per system, MTBF = 4,650 hours; comprising 9 types of SRUs
- **Equipment density**: 3,645 platforms total
- **OPTEMPO**: 141 hours per month per system for 20 year service period
- **Support system**: two-level maintenance with nominal performance characteristics (e.g., 4-hour troubleshoot, remove, and repair; 45-day turn-around on LRU maintenance; cost of repair at sustainment level = 22% of production unit cost)
- **Caveats**: data constructed for this analysis by analogy with systems fielded and in design, representative of such systems, but not data from any specific system

Method

- Used Logistics Support Activity (LOGSA) Cost Analysis Strategy Assessment (CASA) model as primary tool
- Added spares holding cost manually—not addressed in CASA*
- For LRU vs. LRM comparison, used results of recent study by Army Material Systems Analysis Agency (AMSAA) for Future Combat Systems (FCS) program to parametrically adjust CASA spares cost
  - CASA not well structured for such a comparison
  - AMSAA analysis used Selected Essential-item Stock for Availability Method-Life Cycle Cost (SESLCC) model
  - CASA and SESLCC calculated spares costs for LRU case are comparable, hence parametric adjustment is reasonable approach**

*Holding costs include cost of capital, losses due to obsolescence, other inventory losses, storage costs

**Model descriptions in backup

Limitations on Analysis

- Examined sum of classic operations and support (O&S) and field-level spares cost
- Did not address RDT&E or production costs other than spares
- Did not address sustainment (wholesale) level spares costs or support equipment costs
- Treated sustainment-level repair costs as material costs (i.e., labor implicit in material)
- Since time frames for all analysis are identical did not discount
- Did not examine changes in unit cost, which “usually” decreases as failure rate decreases

Quantification of Dimensions

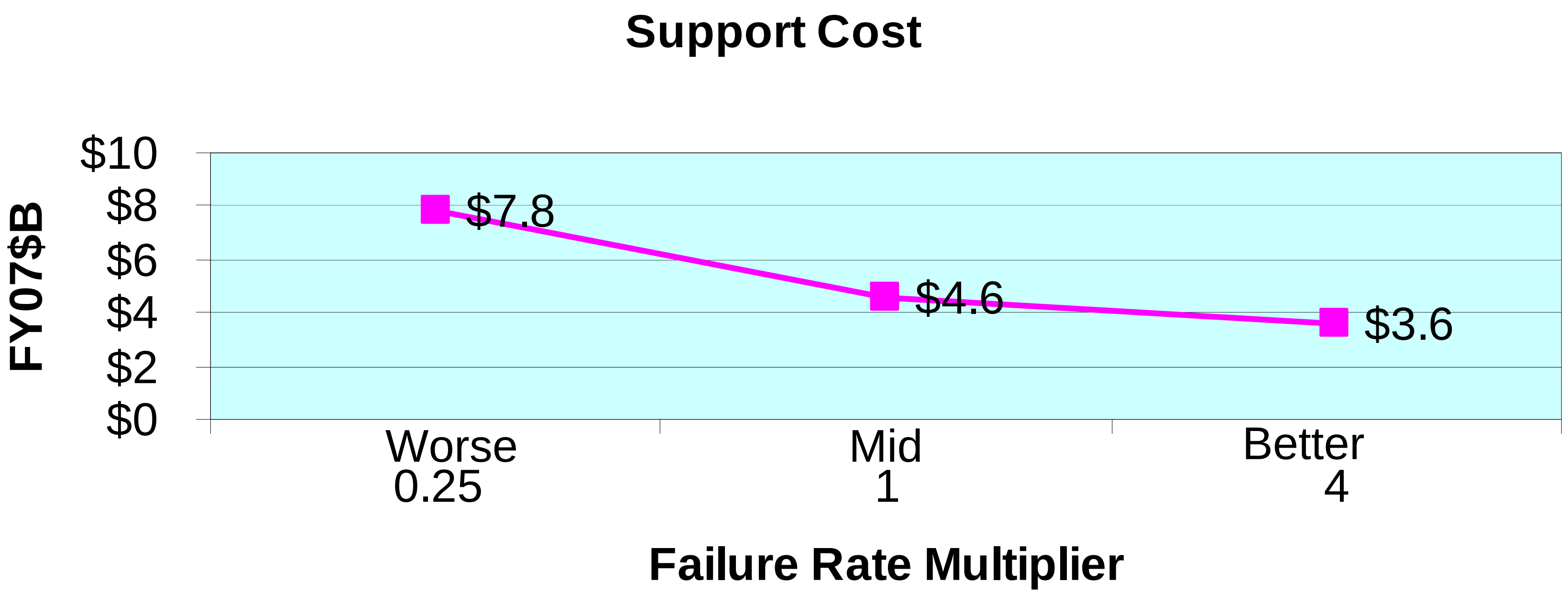
Dimension	Operationalized As	Units
Reliability	Failure rate (1/ MTBF)	Failures per 1,000 hours
Maintainability	Mean time to repair (MTTR)	Hours
Component Packaging	LRU format or LRM format	NA
Commonality	Number of distinct configurations of functionally equivalent systems	Count
Performance of support system	Turn-around time from field to depot and back	Days

Experimental Design

Dimension	Worse	Mid	Better
Failure rate (system level, per 1,000 hours)	6.7 4*mid	1.7	0.4 0.25*mid
MTTR (hours)	16 4*mid	4	1 0.25*mid
Packaging		LRU	LRM
Commonality (number of different configurations)	8 (8*nominal)	4 & 2 (4 & 2*nominal)	1
Turnaround time (days)	180 4*mid	45	11 0.25*mid

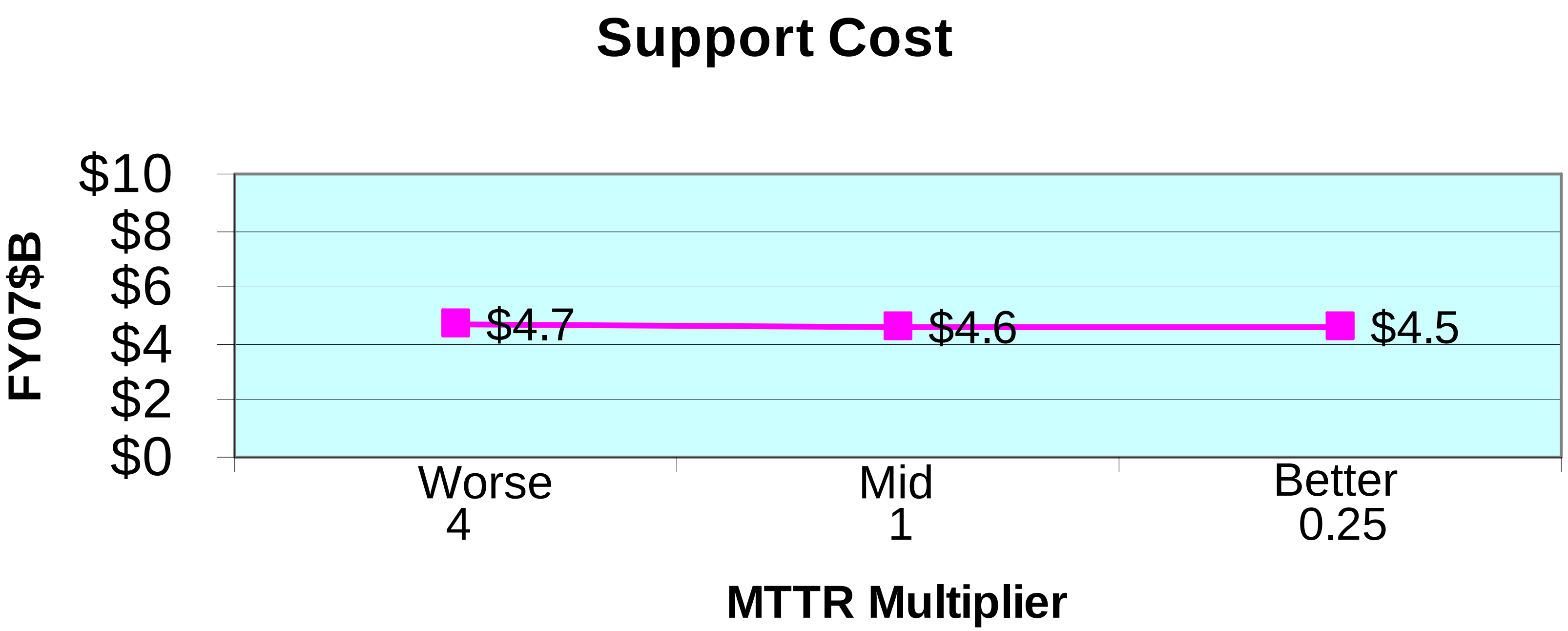
Nominal; base case

Reliability Results



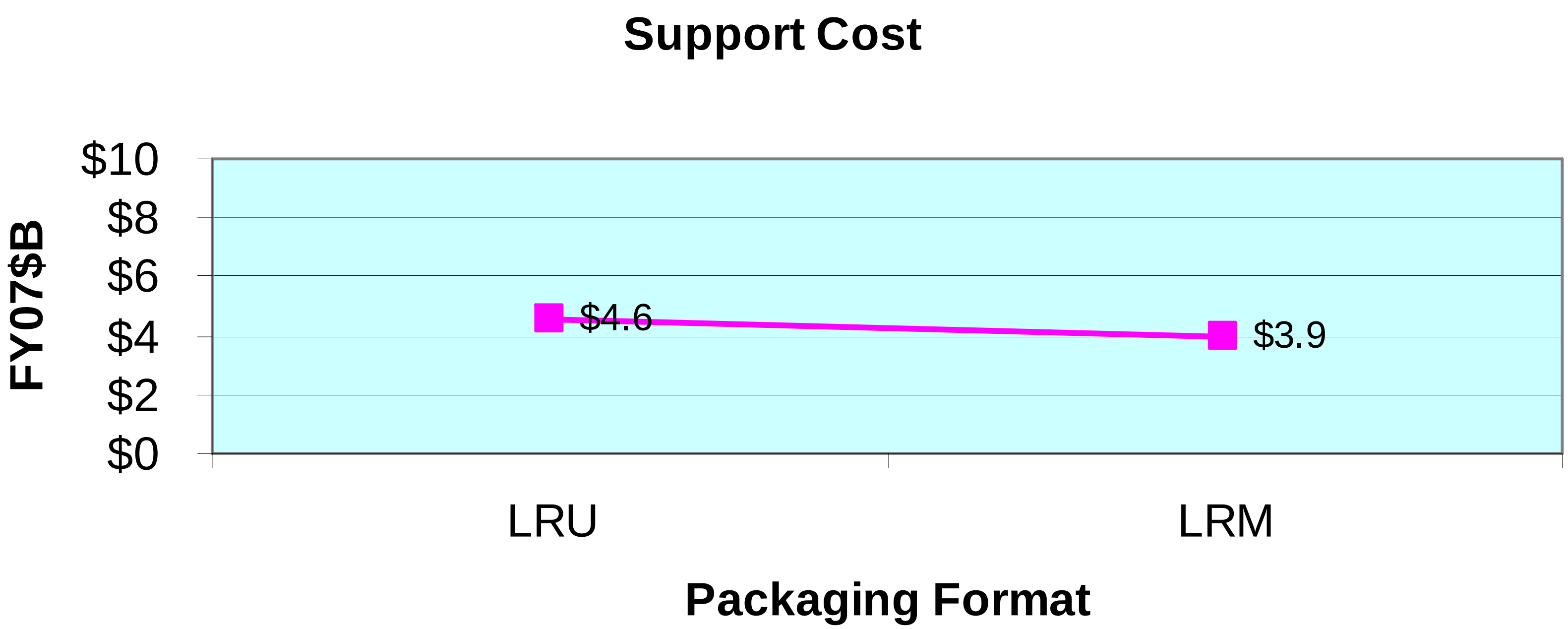
2.19:1 change in support cost

Maintainability Results



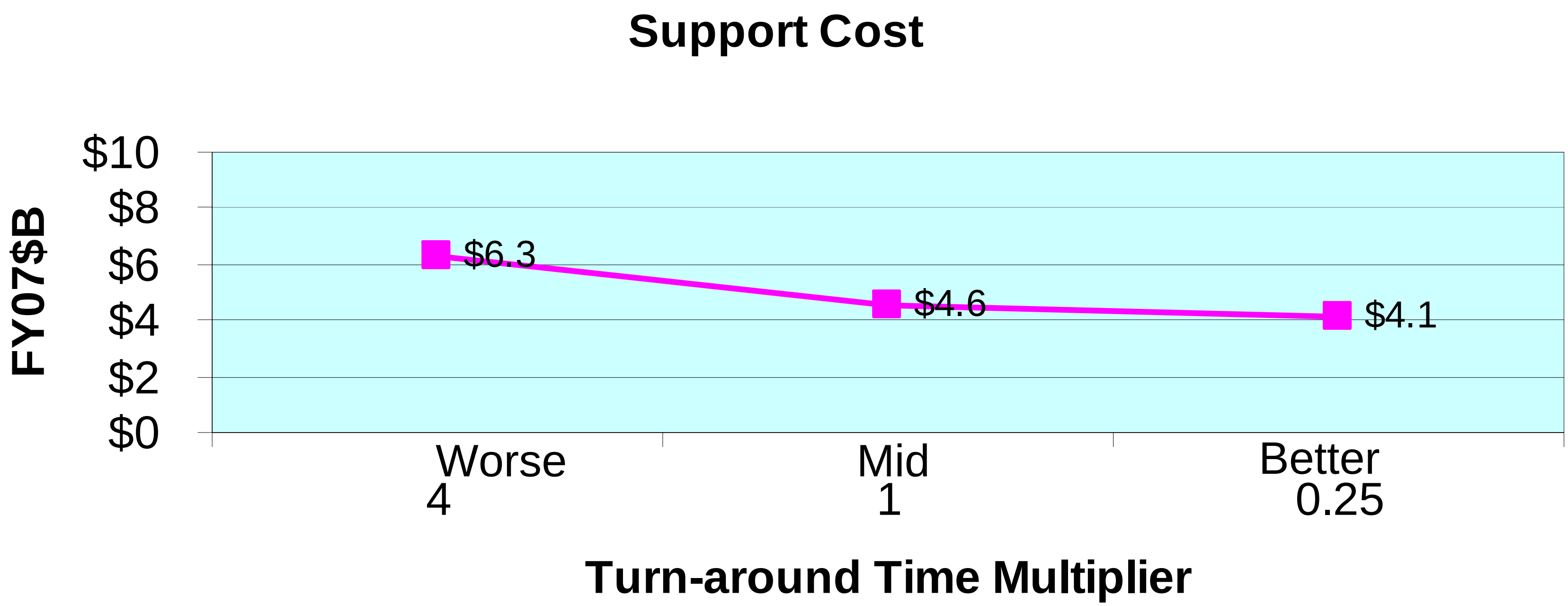
1.03:1 change in support cost
Affects field labor, not spares
But other reasons for maintainability

Component Packaging Results



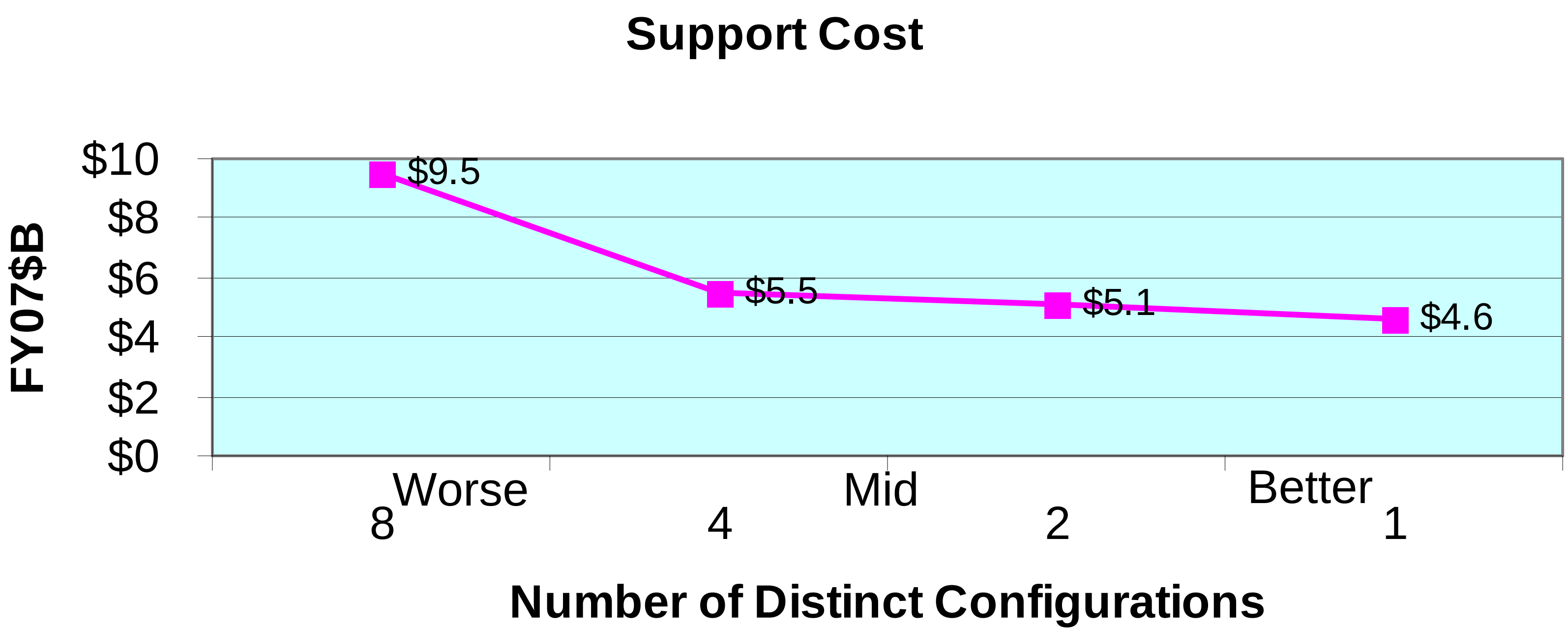
1.17:1 change in support cost

Support System Performance Results



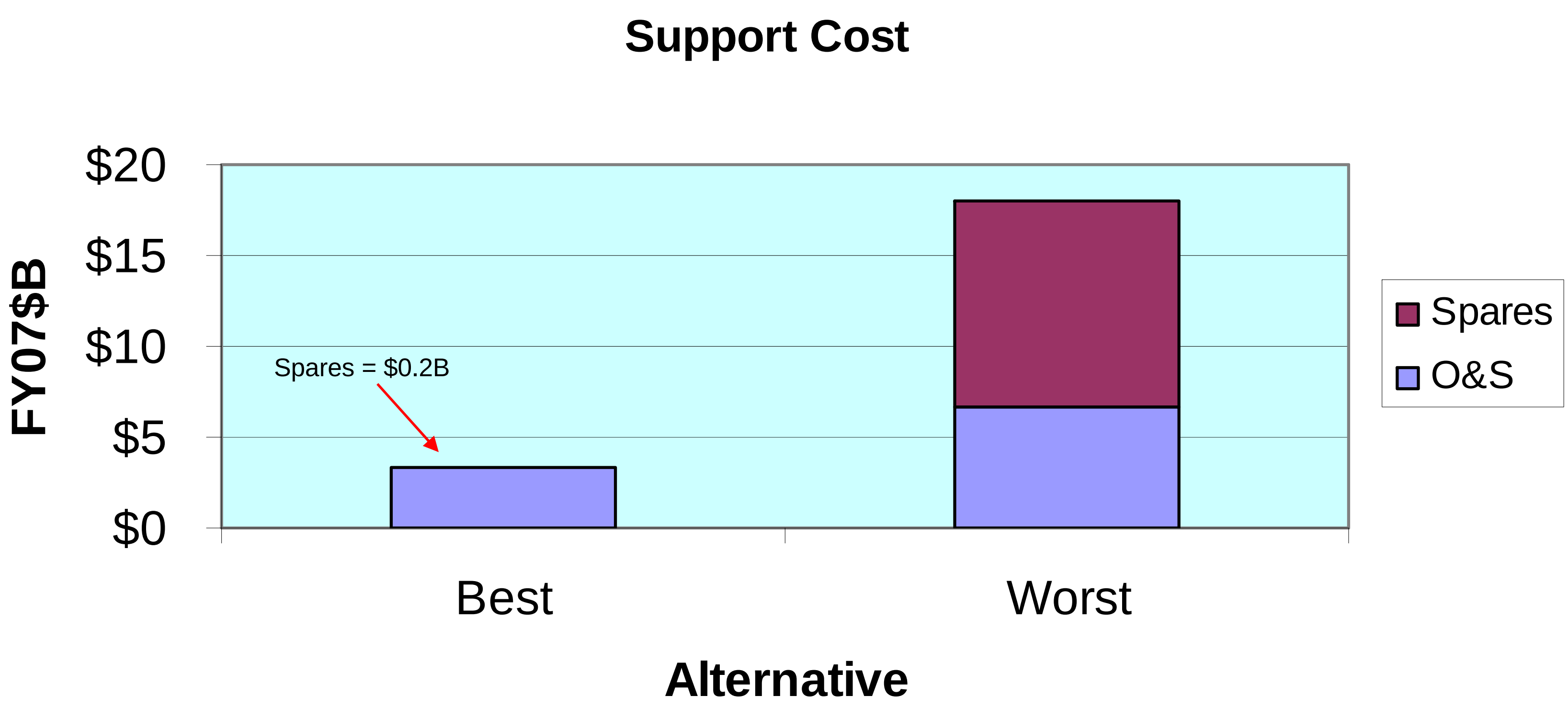
1.53:1 change in support cost

Commonality Results



2.07:1 change in support cost

All Worst Case and All Best Case



5.3:1 change in support cost

Evaluation

(Over Range Examined, Given Characteristics of System Examined)

- Order of impact
  - Reliability (2.19:1)
  - Commonality (2.07:1)
  - Support system performance (1.53:1)
  - Packaging (1.17:1)
  - Maintainability (1.03:1)
- Worst-to-best comparison: > 5.3:1 change in support cost

Interpretation

- All dimensions except maintainability strongly affect support cost
  - All except maintainability affect labor and spares
  - Maintainability affects labor
- Comparing best combined case to worst combined case potential for > 5:1 change in support cost
  - Largest impact comes from design choices: reliability, commonality, packaging
  - Confirms notion that early design decisions “lock in” support cost
  - Since unit cost normally decreases as failure rate decreases, may be underestimating
- Results intended to be representative of complex, high density electronics system on mobile ground platforms
- Less complex, lower density systems in other environments likely to have similar trends but different magnitudes

Selected References

1. Dwight E. Collins, “Logistic Support Cost Commitments for Life Cycle Cost Reduction.” LMI, June 1977. (An early but certainly not the only early look at reliability, maintainability, and cost)
2. Mark I Knapp and Joseph W. Stahl, “Assessment of Avionic Equipment Field Reliability and Maintainability as Functions of Unit Cost,” Presentation to the 16th Annual Department of Defense Cost Analysis Symposium, October 4-7, 1981 (Established a direct log/log relationship between unit cost and failure rate)
3. James A. Forbes, Donald W. Hutcheson, and Beirn Staples. “Using Technology to Reduce Cost of Ownership.” LMI LG404RD4, April 1996 (Showed the relative contribution to ownership cost of reliability and maintainability. Sized the potential for ownership cost return on investment in reliability-related technologies, compared relative return on reliability to maintainability)
4. Dennis L. Zimmerman, et al., “Quantifying and Trading Off the Benefits of Reducing Order and Shipping Times.” LMI LG501R1, September 1997 (Examined cost benefit of support system performance improvement)

backup

Models Compared

Cost Analysis Strategy Assessment (CASA) Model

- Accounting model with embedded spares algorithms*
- Developed by Defense Systems Management College
- Maintained by Army Logistics Support Activity
- Calculates the total cost of ownership including research, development, test, and evaluation (RDT&E); acquisition and production; operations and support; and disposal

Selected Essential-item Stock for Availability Method (SESAME) Model**

- Army standard initial provisioning model. Optimizes the mix and placement of spares to achieve an end item operational availability (Ao) requirement or the maximum Ao for a dollar goal input
- Maintained by Army Material Systems Analysis Agency.
- SESAME becomes SESLCC model when augmented with additional logic to capture other support costs.
- Does not address RDT&E or production other than spares

*CASA 2002 embedded documentation (March 2003)

**http://findarticles.com/p/articles/mi_qa3766/is_200207/ai_n9127603

EXPEDITIONARY FIRE SUPPORT SYSTEM

Ammunition Qualification Test Program

Agenda

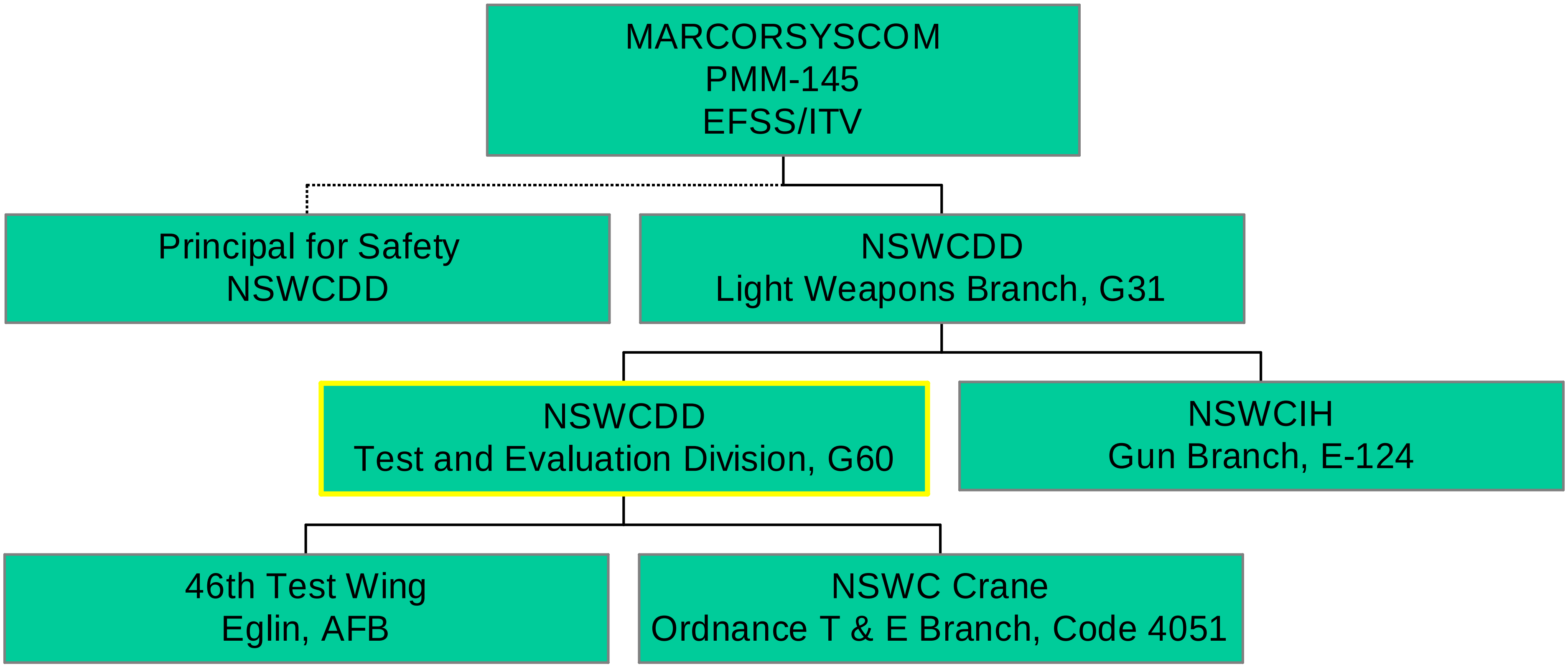
- Program Overview
- System Description
- Test Program
- Lessons Learned

Program Overview

- Program Sponsor - MARCORSYSCOM, PMM-145
  General Dynamics Ordnance and Tactical Systems, Prime Contractor
  - Rapidly field the system with four ammunition variants
  - Internally transportable in the V-22

- NSWCDD and NSWCIH Tasked to Qualify Ammunition
  - NSWCDD, G31, Light Weapons Branch
  - NSWCDD, G60, Test and Evaluation Division, plan, coordinate and conduct test activities
  - Test program started in August 2005.
  - Qualification ammunition delivered in December 2005, major tests completed by November 2006

Test Program Organization



EFSS Mission

EFSS is a "close supporting, all weather, quick responsive indirect fire system supporting Marine Expeditionary Units in the Ship-to-Objective Maneuver" providing accurate fires from with the 120mm rifled towed mortar to 8.1km. The major components of the EFSS are the 120mm rifled towed mortar weapon, the weapon prime mover, a suite of 120mm rifled ammunition, the ammunition supply vehicle, an ammunition trailer, and the ballistic control computer.

The EFSS will be the principal indirect fire support system for the vertical assault element of a Ship to Objective Maneuver (STOM) force.

The EFSS will be employed within the Ground Combat Element (GCE) of the Marine Air Ground Task Force (MAGTF).

Operated by a five-man crew, the EFSS provides indirect fire support that can be directed over friendly troops and out to ranges of 8.1km.

Development, Procurement & Urgency

- Development
  - IM compliant fill for High Explosive Round
  - Modifications to the ammunition containers
  - Qualification Testing
- Procurement
  - LRIP Decision June 2006
  - Full Rate Production August 2007
  - IOC August 2007
- Urgency
  - Mission Need Statement (April 2001)
  - IOC FY2007
  - High Priority USMC Program

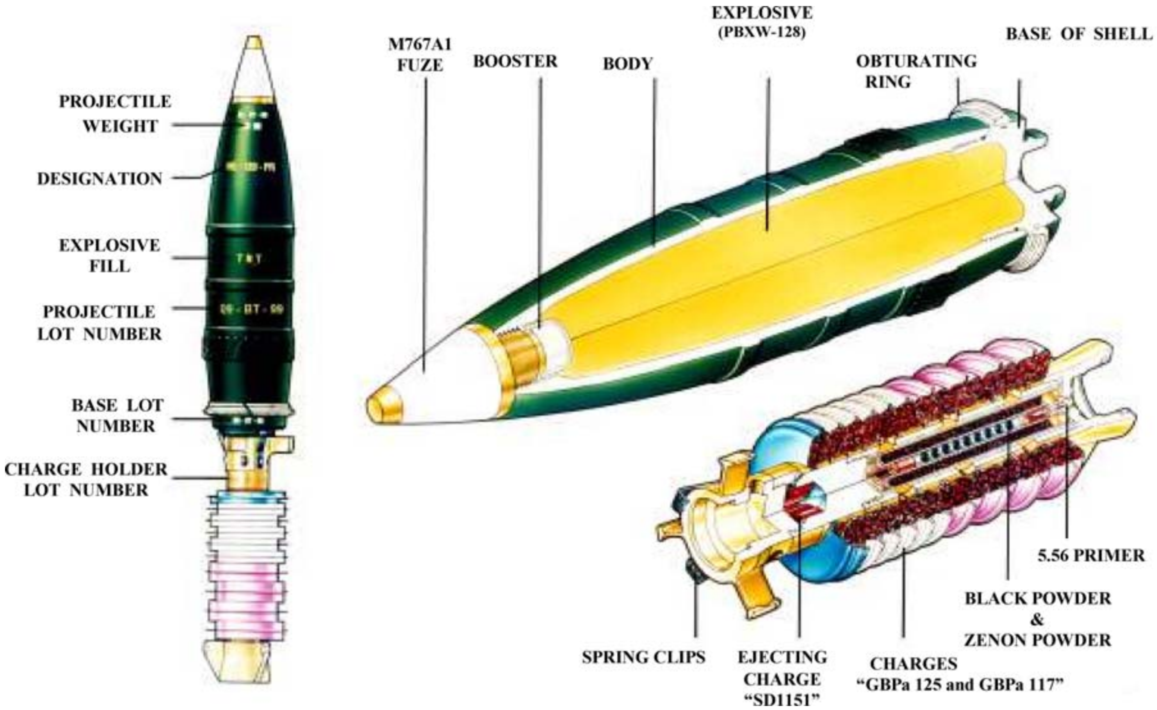
XM327 120mm Rifled Towed Mortar

- Original Design in Service Since 1971
  - Fielded by four NATO countries and Japan
  - Estimated 500,000 founds fired
- Operated By a Five-man Crew
- Spin Stabilized Projectile Provides Improved Accuracy

Ammunition Suite

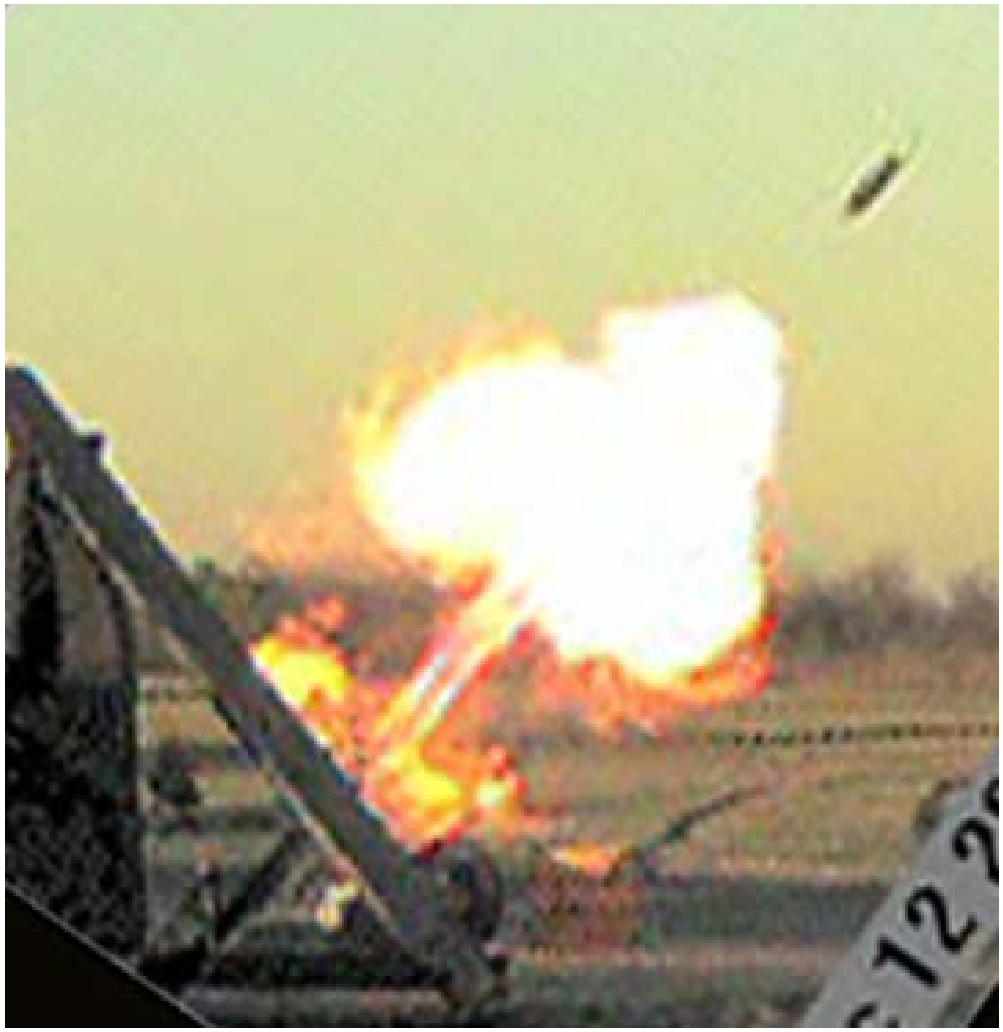
- EFSS Will Be Deployed With Four Types Of Rounds
  - XM1101 High Explosive (HE) w/IM modifications
  - XM1103 Smoke (White Phosphorous (WP))
  - XM1105 Illumination (ILLUM)
  - XM1107 Practice (PRAC)

Ammunition



PROJECTILE WEIGHT
DESIGNATION
EXPLOSIVE FILL
PROJECTILE LOT NUMBER
BASE LOT NUMBER
CHARGE HOLDER LOT NUMBER
M767A1 FUZE
BOOSTER
BODY
EXPLOSIVE (PBXW-128)
OBTURATING RING
BASE OF SHELL
5.56 PRIMER
BLACK POWDER & ZENON POWDER
SPRING CLIPS
EJECTING CHARGE "SD1151"
CHARGES "GBPa 125 and GBPa 117"

Ammunition

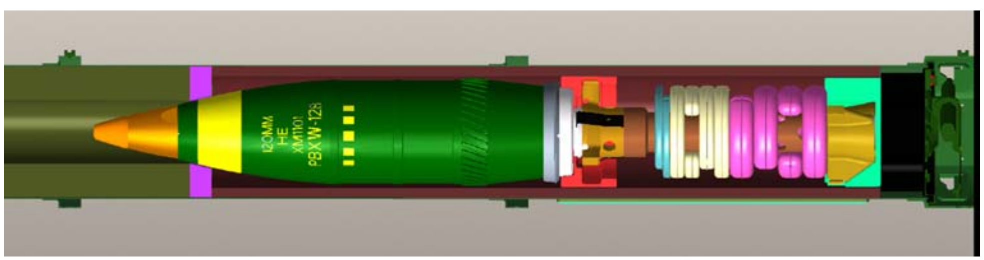


Ammunition Trailer

- Loaded 6X5 Horizontally for Vehicle Transport and Palletized 6X6 Horizontally for Shipping (XM1101 HE, XM1105 ILLUM, and XM1107 PRAC Rounds)
- Loaded 5X5 Vertically for Vehicle Transport and Shipping Palletized (XM1103 SMOKE Rounds)

EFSS Ammunition Shipping/Storage Container

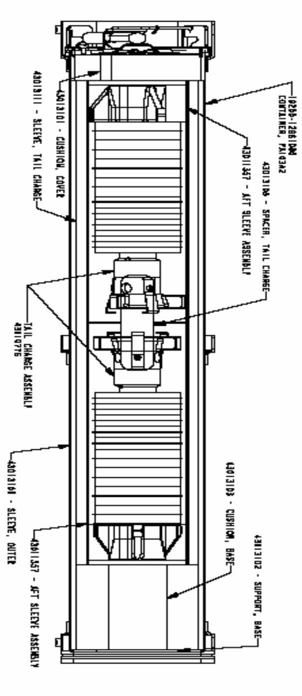
- Rounds Packaged in Metal Ammunition Containers
  - PA117 vented and PA103 containers
- Blowout Panels for Rapid Out-Gassing Venting
- Relief Valve for Slow Out-Gassing Venting
- Performance Oriented Packaging (POP) Certification Complete

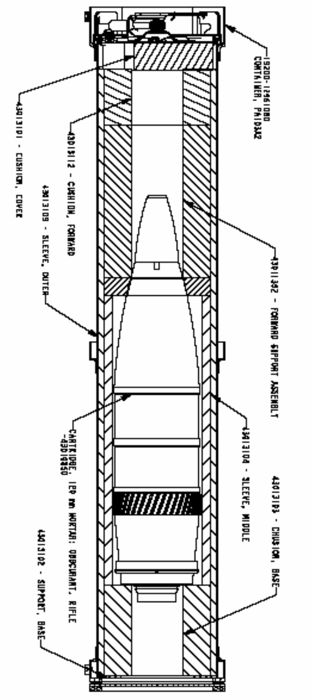


EFSS Ammunition Shipping/Storage Container (Cont'd)

- XM1103 Smoke Round Packaged Separately From Its Tail Charge to Allow for Vertical Palletizing and Transport

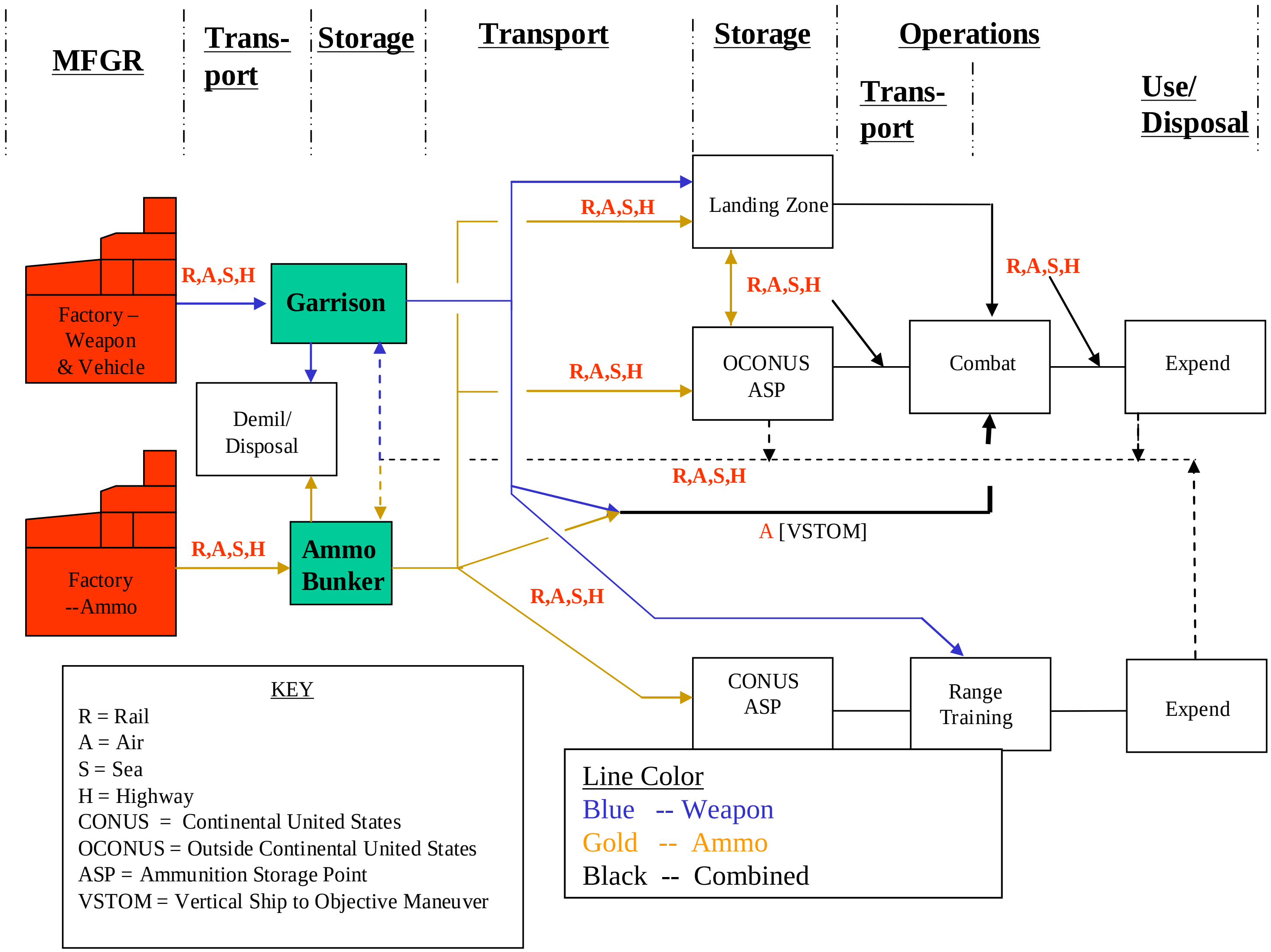
Two Tail Charges Per Container





One Warhead Per Container

Stockpile to Target Sequence



EFSS IM Threat Hazard Assessment (THA)

- THA Conducted in January 2005
- Threats Analyzed
  - Thermal environments produced by hydrocarbon fuel fires
  - Shock environments produced by detonation of other weapons
  - Impact environments by bullets, fragments, shaped charge jets, spall
- Determined Tests To Conduct
  - Slow Cook-Off (SCO)
  - Fast Cook-Off (FCO)
  - Bullet Impact (BI)
  - Fragment Impact (FI)
  - Sympathetic Detonation (SD)
  - Shaped Charge Jet Impact (SCJI)
- Determined Test Not To Conduct
  - Spall Impact (SI) – not transported or stored in armored vehicle or armored enclosure

TEST PROGRAM

- Harmonized IM and Hazard Classification Test Plan.
- Comprehensive Environmental/Durability Test Series.
- Collaboration Between NSWCDD, NSWCIH, NSWCCD And Eglin AFB for test execution.

HARMONIZED IM/HC TESTS

- 12 HE AURs
  12 Illum. AURs
  12 Practice AURs
  12 Smoke Proj
  12 Tail Charges
  - V & R I
  - 28 – Day T&H
  - V & R I
  - Vibration Tran/Ship/Helo
  - V & R I
  - 4 – Day T&H
  - V & R I
  - 40 Foot Drop

- 9 HE AURs
  9 Illum. AURs
  9 Practice AURs
  6 Smoke Proj
  W/6 Tail Charges
  - V & R I
  - Fast Cook Off

- 2 HE AURs
  2 Illum. AURs
  2 Practice AURs
  2 Smoke Proj
  2 Tail Charges
  - V & R I
  - Slow Cook Off

- 2 HE AURs
  2 Illum. AURs
  2 Practice AURs
  2 Smoke Proj
  2 Tail Charges
  - V & R I
  - Fragment Impact

- 2 HE AURs
  2 Illum. AURs
  2 Practice AURs
  2 Smoke Proj
  2 Tail Charges
  - V & R I
  - Bullet Impact

- 18 HE AURs
  18 Illum. AURs
  18 Practice AURs
  18 Smoke Proj
  18 Tail Charges
  - V & R I
  - Symp Det./Stack

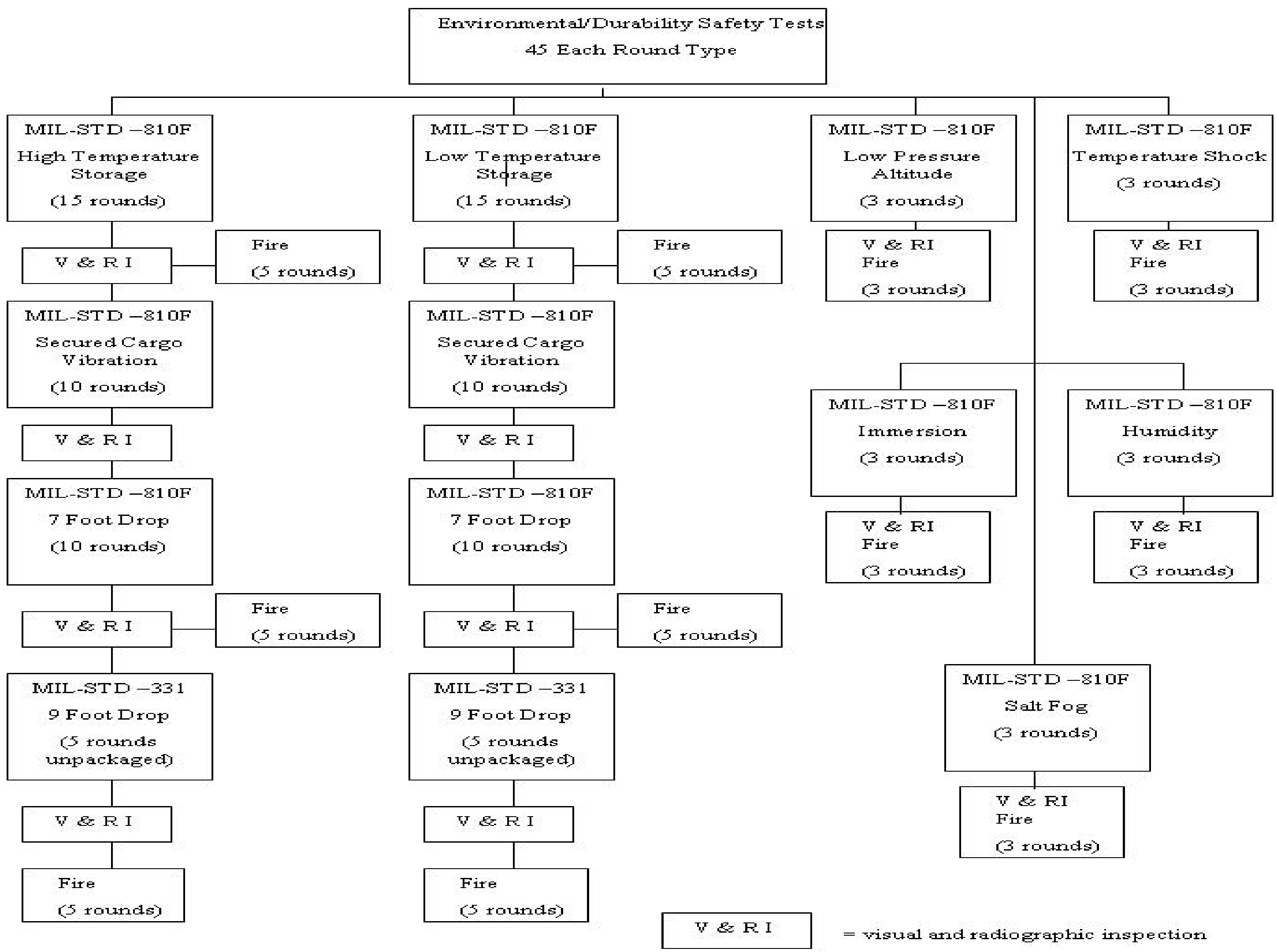
- 2 HE AURs
  - V & R I
  - Shaped Charge Jet Impact

LEGEND

AUR – All up round

V & R I – Visual and radiographic inspection

ENVIRONMENTAL/DURABILITY



TEST CHALLENGES

- Schedule
  - Concurrent work
  - Incorporating packaging changes into work flow
- Large Number of Tests
  - 44 IM tests total
  - 105 Environmental tests total
- Volume of Data
- Hazard Classification of Mixed Smoke Pallet

EARLY TEST RESULTS

- Packaging Problems At High Temperature
  - Non-hazardous off gassing produced overpressure
  - One way check valve installed
- Support Dunnage Problems During Vibration
  - Aft support broke down during transportation vibration at temperature
  - Dunnage redesigned and rounds repackaged
- Tests Repeated

TEST RESULTS

- Planned Tests Completed, Regression Testing Underway
  - Packaging changes
  - IM signature, ammunition performed well
- Gun firing at NSWCDD and Hawthorne, NV

Lessons Learned

- Leverage Test Facilities and Capabilities
  - Schedule
  - Idea sharing
- Quick Response of PMO and Prime Contractor Invaluable
- Communication = Flexibility

Questions?

OPERATIONAL ANALYSIS OF CBM+ TO ENHANCE SYSTEM SUITABILITY

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Science Advisor, DOT&E

SCENARIO:PROBLEM SETTING

- ***ASSETS***:VEHICLES, A/C; for ***MISSIONS***
- ***BECOME FAILURE-PRONE, "UNHEALTHY" WITH WEAR, USAGE, "AGE" (RANDOMLY)***
- ***ASSUME: HEALTH CONDITION "KNOWABLE" (SOMETIMES,… WITH ERROR)***
- **→*MONITOR HEALTH CONDITION* (e.g. helo rotor vibration ↑)**
- ***DIAGNOST. SYMPTOMS (DS): COST ↓***
- ***AVAILABILITY↑***

(<u>PROVIDED</u> CBM+ SYSTEM FUNCTIONS & WITH FEW MISTAKES!)

- ***Client: e.g. Army Aviation& Missile Cd., Redstone Ars.; Analyst. Data Whse.***

Condition Indicator (CI) Development Summary

Demonstrated Capabilities:

- Vibration CIs Determined From Analysis of Frequency & Energy Data Recorded By Embedded Sensors
- CI Development Is Iterative And Requires High Quality Field Data To Determine Normal and Abnormal Behavior
- CI Development Is Further Enhanced With Bench Test Data
- Each CI Is Tailored For Individual Fault Modes
- The Complexity Of CI Development Varies With:
  - The Number Of Fault Modes
  - Fault Occurrence Frequency
  - The Monitoring Capability For That Mode

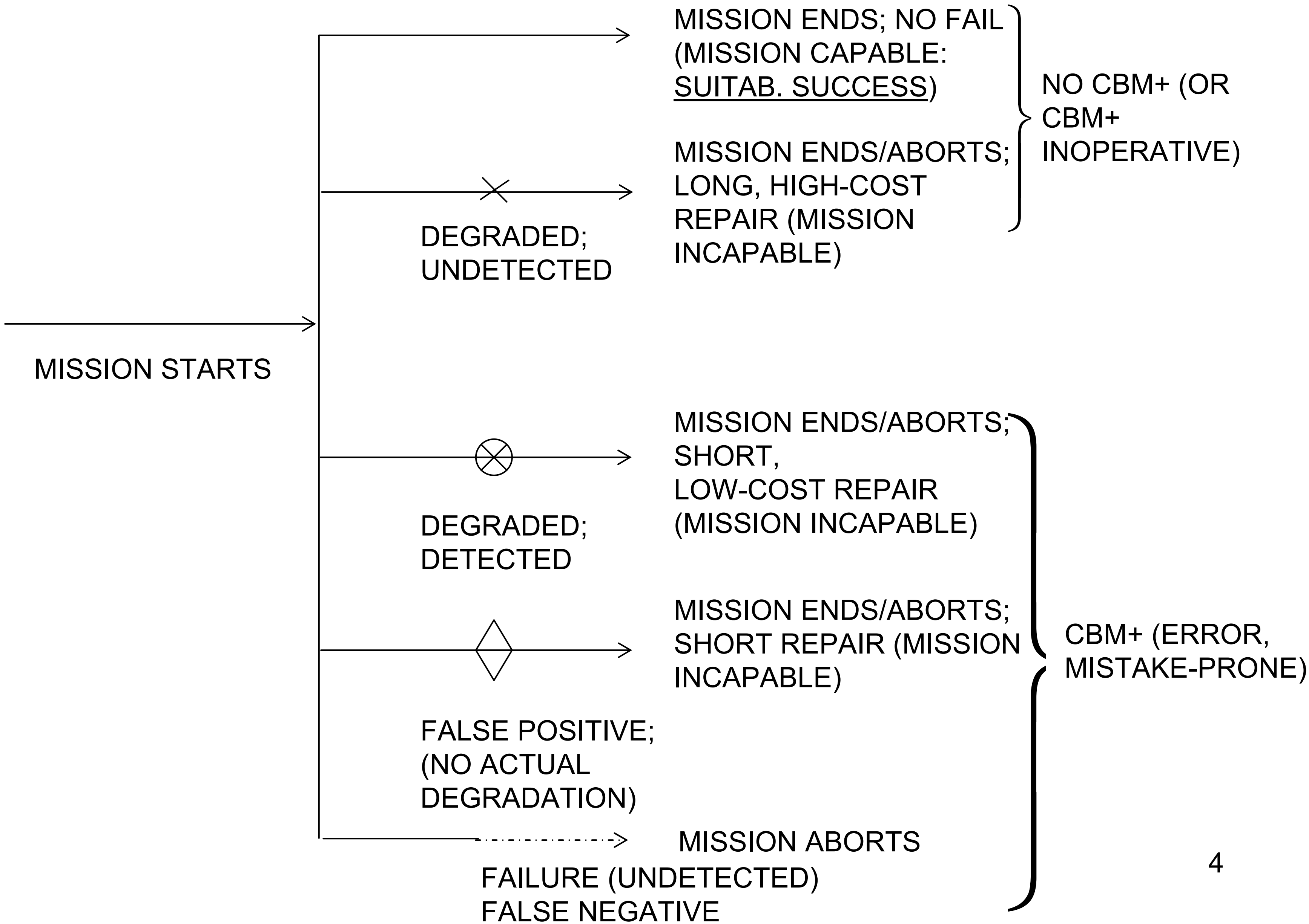
Benefits To The Warfighter:

- Teardown Inspections Are Used To Confirm CI Thresholds
- Replace Manual Inspections With Active Monitoring

Objectives:

- Extends Time Between Overhauls & Extends Service Life
- Increases Safety

OUTCOMES
WITHOUT/WITH CBM+



Additional CBM+ Failure Modes

- CBM+ Physical System Failures
- Prognostic Errors
  - CBM+ False Positives (No Actual Fault)
  - CBM+ False Negatives (Actual Undetected Fault)
- T&E of System, Including CBM+ ≡ IVHM,

VITAL!

  - "End to End"

Periodic Overhaul vs. Prognostics (IVHM or CBM+) Previous Work

- [IDA: FCS] (Macheret, Koehn, & Sparrow)
  - CBM+ system is perfect but not all (series) system components monitored
  - CBM+:

    KNOWN (!) Time from Prognostic→ Failure (*NO ERROR*)
  - Result: CBM+ Cost↓, AVAIL. ↑ vs. Periodic Overhaul (*If* sufficiently many sub-systems successfully monitored)

Periodic Overhaul vs. Prognostics (IVHM or CBM+) Previous Work

- [BOEING] (Z. Williams, S. Cooper, J. Vian)
  - Integrated Vehicle Health Management (IVHM)=CBM+
  - Fault isolation time log-Gauss; outliers. Simulation
  - Result: Optimistic assumptions → Availability ↑, Cost ↓

Preventive Maintenance (Including CBM+)

- Text: Gertzbach, I. **Reliability Theory** with Application to Preventive Maintenance (Chap. 4, Sec 4.2) Springer

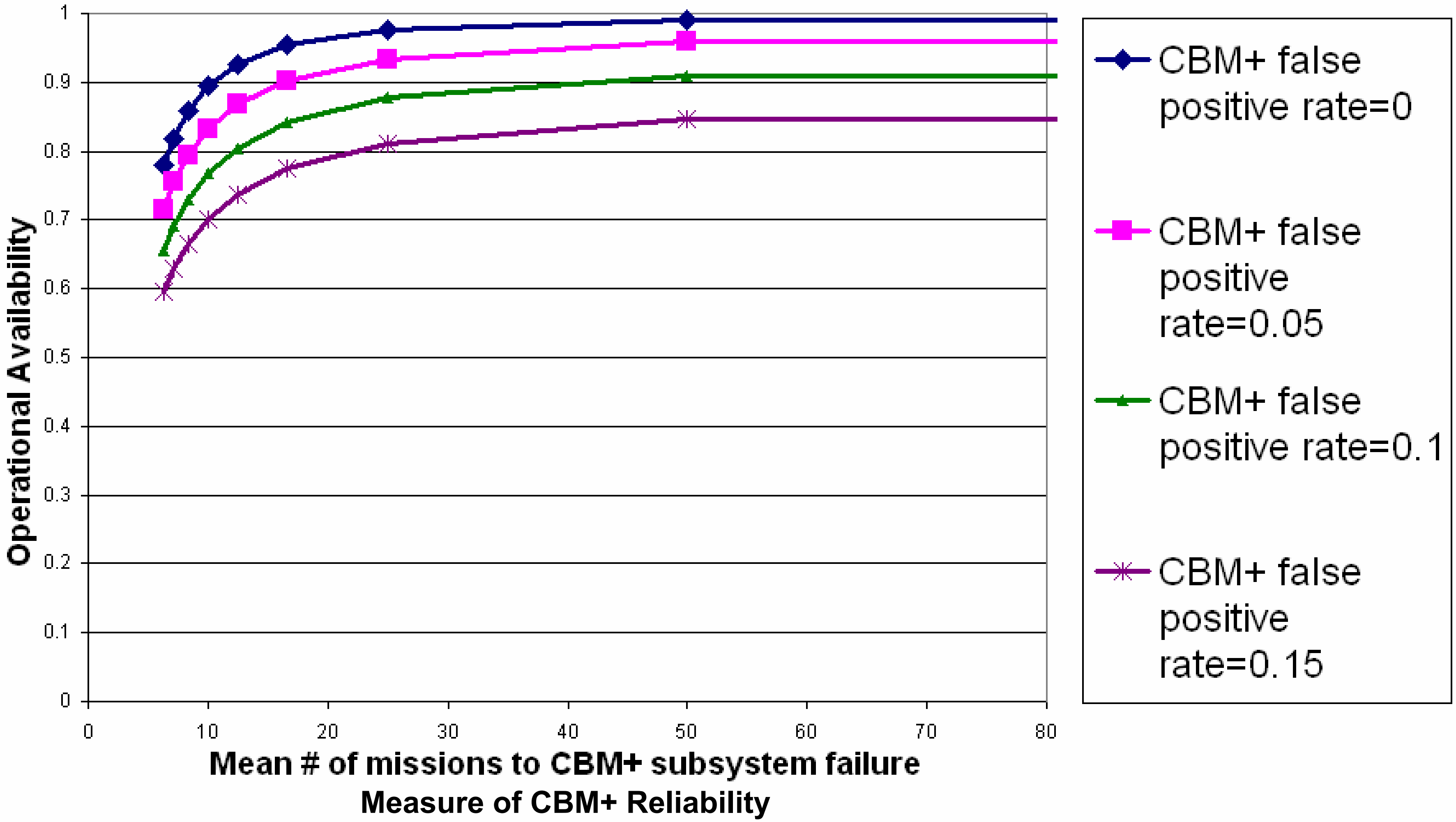
Present Model

- CBM+ subsystem imperfectly reliable: subject to functional/ “physical” failure and repair
- If CBM+ subsystem up prior to a mission & *produces a signal*, the system will undergo repair/replacement
  - True positive: System would have failed during mission
  - False positive: System would not have failed during mission
- If CBM+ subsystem up prior to a mission & *does not produce a signal*, the system is used on the mission
  - False negative: System fails during the mission (catastrophic failure)
  - True positive: System completes mission
- Independent, identically distributed missions

Availability Parameters

- Mean repair times (Multiple of Mission Times, e.g. 4 hrs.)
  - CBM+ subsystem failure: 10 (40 hrs.)
  - Detected failure: 15 (60 hrs.)
  - False Positive: 5 (20 hrs.)
  - Catastrophic Failure: 35 (140 hrs.)
- Mean number of missions between operational system failures (not CBM+)
  - 100 (400 hrs.)

Operational Availability



System Operational Availability Depends Upon

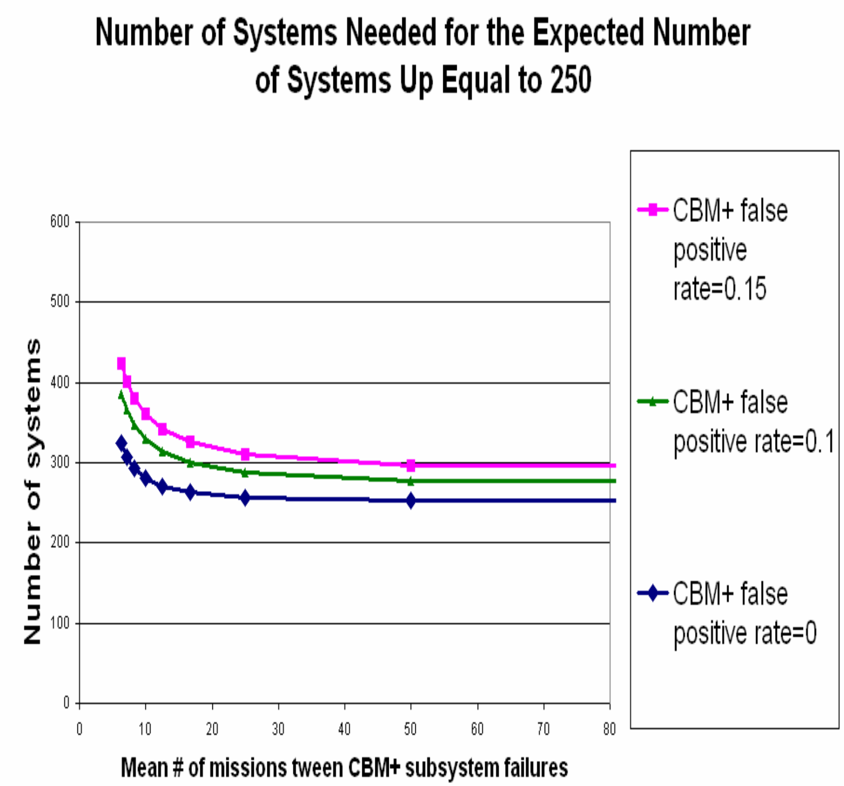
- Reliability of the CBM+ subsystem
- The false positive rate
- The rate of true positives (repair time of failures)
- The rate of false negatives (repair time is larger for catastrophic failures)

Number of Systems

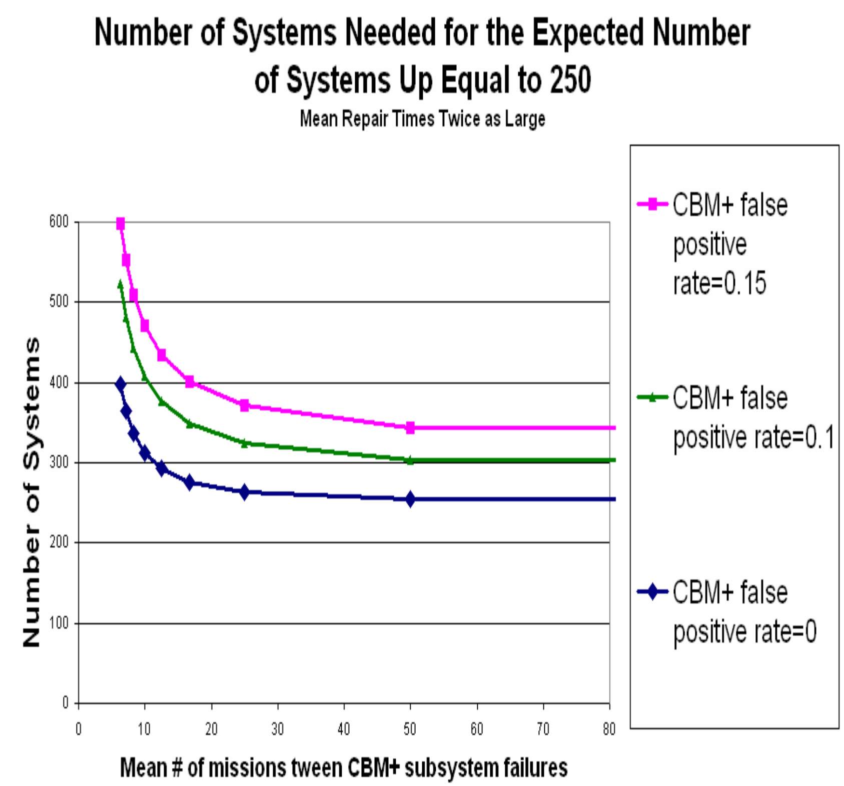
- Systems operate and are repaired independently of each other, and have the same parameters.
- There is a need for 250 systems to be available that can be assigned to missions

Number of Systems Required

All mean repair times twice as large



(CBM+ Reliability)



(CBM+ Reliability)

Number of Systems Needed Depends Upon

- Reliability of the physical system
- Reliability of CBM+ subsystem
- Mean repair times
- Rate of false positives

Suitability

- Not just a "requirement": Essential for Mission Success
- Affordability issue:

  Reliability of CBM+ & System (A/C) ↑

  Spare (Logistics) Cost ↓

Fixed Budget B

- Develop/Test Physical System & CBM+ subsystem
  - MTTF
  - Operational Availability
- Use remaining budget to buy systems to be fielded
- Mean number of fielded systems up

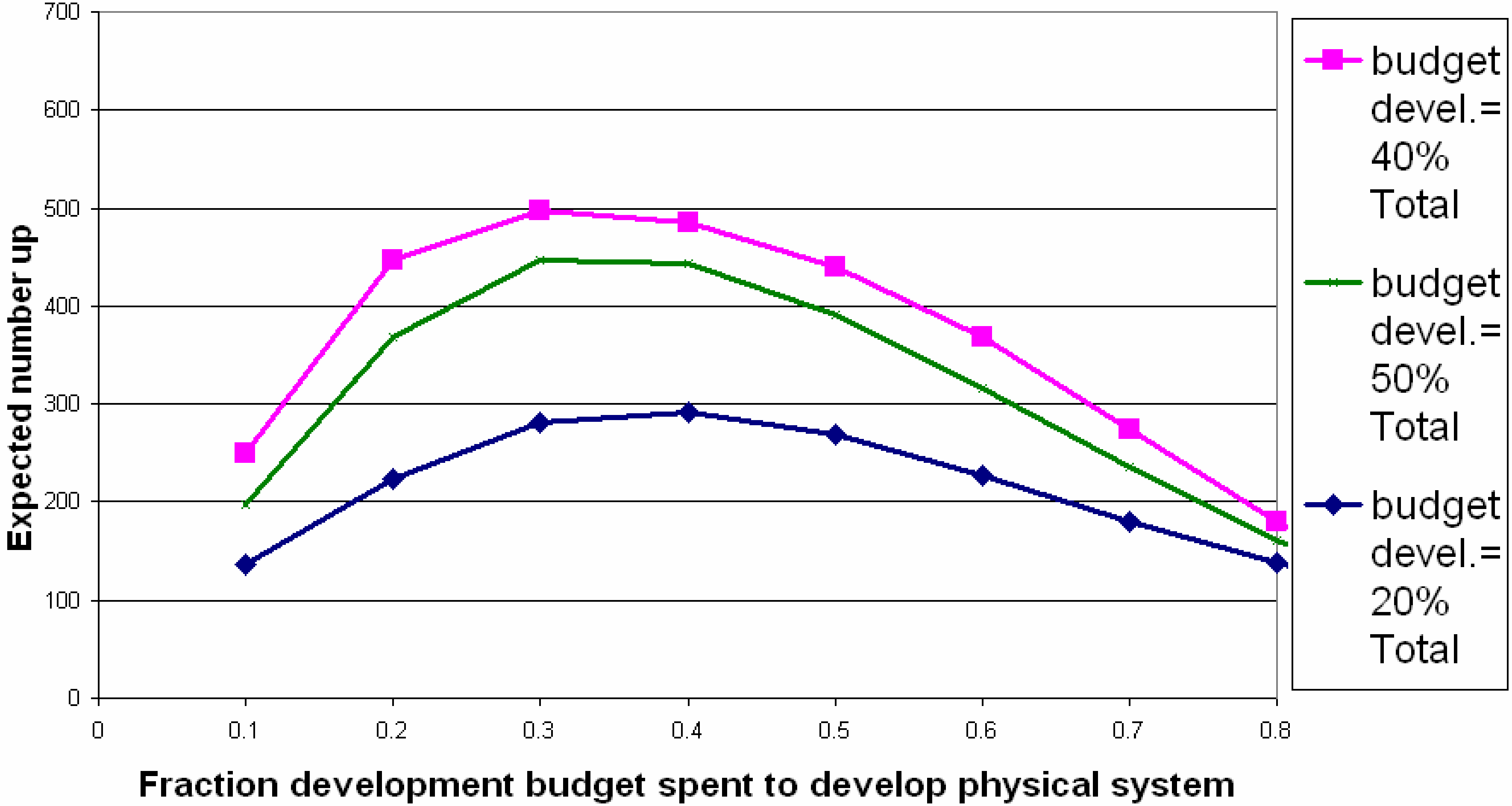
Tradeoffs

- Less $ spent on development/testing
  - Buy more systems
  - Less operational availability
- More $ spent on development/testing
  - Buy fewer systems
  - More operational availability
- Fraction of development/testing budget spent on CBM+
  - Less: operational availability ↓

Decision Variables

- Amount of budget to spend on development/testing
- Fraction of development budget
  - Physical system
  - CBM+ subsystem
- Rest of budget to buy systems

Expected Number of Fielded Systems Up



Remarks

- The maximum expected number of fielded systems available to start a mission is obtained by allocating (about) 40% of the total budget to development/testing
- The best allocation of the development budget:
  - 30% system development
  - 70% CBM+ subsystem development

Conclusions

- CBM+ has the promise to improve system reliability and to decrease maintenance costs.

However:

- CBM+ can introduce additional failure modes.
- Reliability of CBM+ & System ↑

  Spare (Logistics) Cost ↓
- Developmental and operational testing of the system *MUST* include the CBM+ subsystem.

Industrial Committee on Operational Test and Evaluation (ICOTE)

Larry Graviss, Jacobs Eng.
Committee Chairman

Dr. Charles McQueary,
DOT&E,
Co-Chairman

James F. O'Bryon
Chairman, NDIA T&E Division

13 March 2007

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

ICOTE Organizing Principles

The objectives of the ICOTE are to:

- Provide a forum for discussion and exchange of T&E views from Defense and the Industrial Base in a non-attribution environment
- Gain feedback from senior industry representatives and OSD leadership
- Discuss OSD and service policies which affect relationships with industrial suppliers
- Discuss emerging issues / policies in government and industry which affect the readiness and capabilities of U.S. defense system producers
- Cooperate on various projects of mutual benefit to the ICOTE participants

ICOTE
Current Membership

CURRENT NDIA T&E
ICOTE PARTICIPANTS

NDIA PARTICIPANTS

Lt Gen Larry Farrell, USAF (Ret) Pres & CEO, NDIA
Maj Gen Barry Bates, USA (Ret) VP Operations
Sam Campagna; Director of Operations
James O'Bryon: Chair T&E Division

GOVERNMENT MEMBERS

Dr. Charles McQueary DOT&E
David Duma DOT&E
Dr. Ernie Seglie DOT&E
Michele Williams NGA
Jim Streilein ATEC
Brian Simmons AEC
Mike Crisp DOT&E
Maj Gen James Myles ATEC/CG
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Colonel Mike Bohn USMC
Colonel Debra Dexter DISA
Dr. Steve Hutchison DISA
Steve Whitehead OPTEVFOR
Jerry Kitchen AFOTEC

ICOTE
Current Membership

CURRENT NDIA T&E
ICOTE PARTICIPANTS

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Gene Fraser Northrop Grumman
Tom Quinn BAH
Larry Graviss Jacobs Engineering

ICOTE

- **MEETINGS**

  The ICOTE will meet at the call of the Chairman and Co Chairman at sites and times convenient to the members.

  Minutes of the ICOTE will be provided to all members in the form of Agendas and action items as determined by the Director of OT&E.

  Topics of interest for consideration by the ICOTE will be solicited from industry and government members.

ICOTE Themes for The past year

Themes for 2006 /2007

- Net Ready KPP
- Testing in a Joint Environment
- Long Term Tactical Armor Strategy
- Testing in an Evolutionary Acquisition Environment
- M&S in OT&E
- Reliability Sustainability
- Sustainability KPP
- Contractor Logisitics Support
- Information Assurance
- ATD Supportability
- Sustainability and Evolutionary Acquisition
- Joint Rapid Acquisition

Reports

- DAPA Report
- Net Ready KPP Study Report Mar 2006

Headquarters U. S. Air Force

Integrity - Service - Excellence

23rd Annual National Test & Evaluation Conference

Mr. Dave Hamilton

Service T&E Executives Speak

15 Mar 07

U.S. AIR FORCE

Outline

- **AF T&E Update**
- **AFSO21 Initiatives**
- **Early Involvement**
- **Suitability**

Air Force Missiles Fired from UTTR vs WSMR

- ***Utah Test and Training Range (UTTR)***
  - AF Owned and Controlled
  - Ease Scheduling Conflicts
  - Reduced Cost – Fewer Program Schedule Slips

Weapon System Evaluation Program (WSEP)

- **Annual Brief to CSAF**
  - Directed Increased Utilization of Guns Across CAF
    - 83 FWS to Investigate Options to Combat Banner
  - Significant Increase in Missile Firings
    - Improved Confidence Levels
    - Combat Archer Requested ~150/year

Aerial Targets

- **AFSAT (BQM-167A)**
  - Replaces two legacy subscales (BQM-34 & MQM-107)
  - Flight test has been delayed due to reliability issues
- **QF-4**
  - Resolved Control Amplifier Issue Which Caused a 10 Aug 06 Crash At Holloman AFB
  - Resumed to NULLO (Not Under Live Local Operator) Ops
  - Inventory
- **Air Superiority Target**
  - AoA In Progress - ECD Mar 07
  - Program funded for FY08 start

EDO Advance Capability Pod (ACaP) Jammer

- Purchased 6 ACaP Jammers, Support Equipment and Spares in FY05 for $11.65M From EDO Corporation
- Improved Electronic Attack Threat Representation for Aggressors to Better Support CAF Training Requirements
- 1550+ Total Aircrew Exposed to DRFM EA, 500+ Fighter Crews
- “Best EA Training Ever Experienced” Red Flag Aircrew

AFSO21 - 5 T&E Initiatives

- ***Early Tester Involvement***
  - Enhance Value of Test to Acquisition
  - Enhance T&E Efficiency
- ***Integrated DT & OT***
  - Reduce # of Stop Tests and Failures in OT&E
  - Deliver Warfighter Capability Sooner
- ***Information and Data Management***
  - *Enhance T&E Workforce Effectiveness and Development*
- ***Reduce Late Defect Discovery***
  - *Eliminate Cost Overruns*
- ***Optimizing Test Data Requirements***
  - *Minimize Data Collection & Duplication*
  - *Use Common Data Repository*

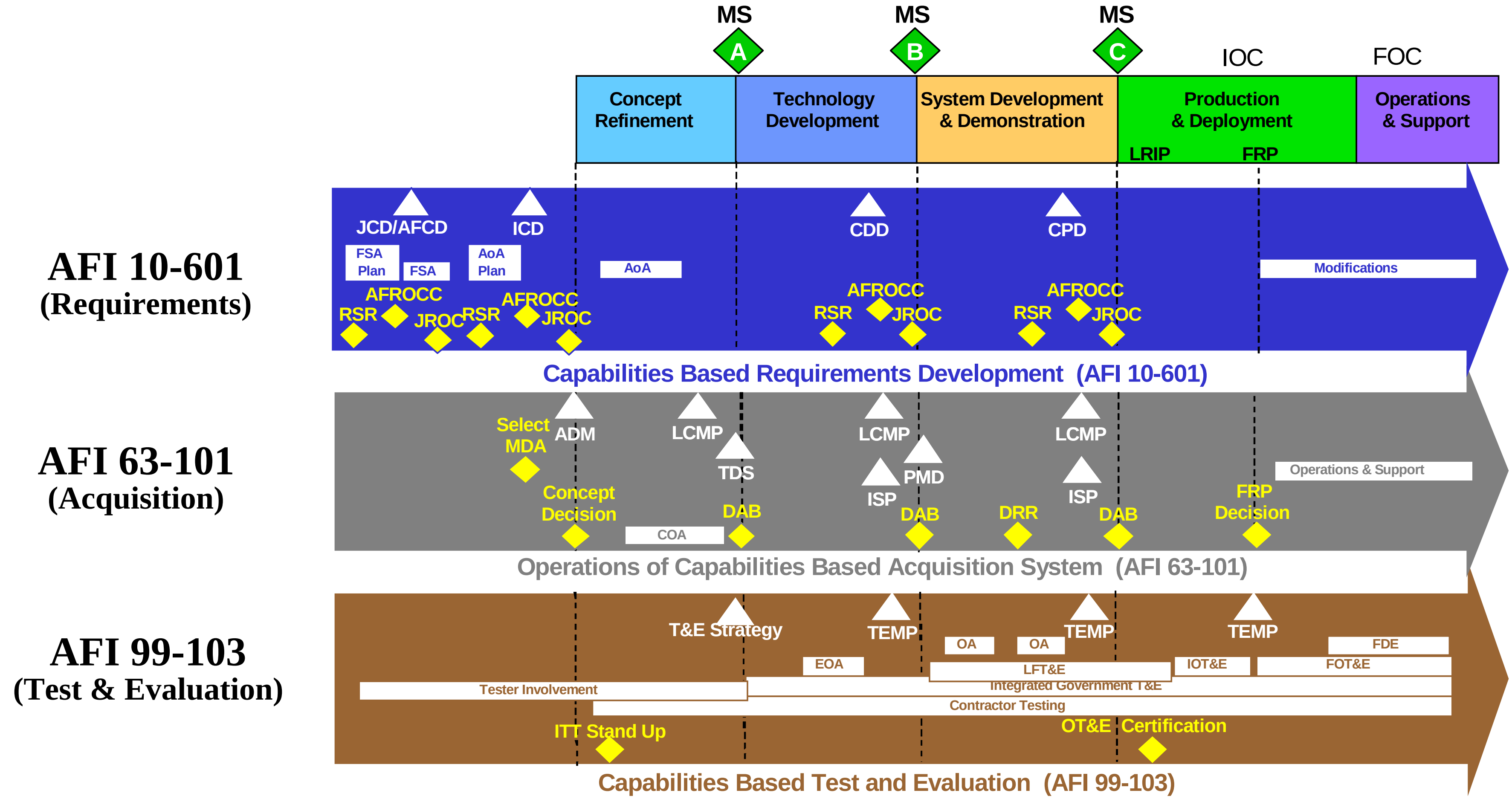
Early Involvement and Integrated Testing <u>Work</u>

Small Diameter Bomb

- **Integrated Test Applied to Initial Seamless Verification Test (DT/OT)**
  - **Enhanced Operational Relevance During CT and DT**
  - **Maximized Opportunity to Use Early Test Data for IOT&E**
- **Results: Fewer Weapon Releases Required for IOT&E**
  - **JDAM = 132 Weapons**
  - **SDB = 28 Weapons**

3 Major Processes Aligned -- Requirements, Acquisition, & T&E

"Collaboration between the requirements, acquisition, DT&E and OT&E communities is key." SAF/AQ (Dr. Sambur) and AFOTEC/CC (MGen Peck), April 02



Suitability

- ***Defense Acquisition Objective:***
  - Field Operationally Suitable Systems
  - Available for Combat when Needed
  - Reliable Enough to Accomplish its Mission
  - Does not Impose an Undue Logistics Burden
- **Operational Test and Evaluation is Statutory**
  - Required to Assess the Effectiveness and Suitability of Defense Systems Under Consideration for Procurement
- **Suitability has a Large Impact on Effectiveness**

U.S. AIR FORCE

Suitability Drivers

- ***Suitability Deficiencies have been Responsible for Many of the Fielding Problems with Newly Acquired Systems***
  - Crucial Suitability Issues are not Adequately Identified Early
  - Not Addressed in Operational Test Plans
  - RAM are Driving Suitability Deficiencies

Suitability Should be Assessed From Early Development Through Fielding

Summary

- **Field Operationally Suitable Systems**
- ***<u>Enhanced early involvement</u> and <u>information sharing</u> will allow us to <u>identify problems early</u>, engage the contractor to <u>find fixes sooner</u>, with the goal of <u>ensuring systems are ready to enter dedicated OT&E with a high probability of passing</u>.****
- **Collaboration is Key to Transformation**
  - Requirements – Acquisition – Test communities

Support Quality Acquisition Through Credible T&E

* "*AFOTEC Ownership of Test Compression Target Programs*," Joint SAF/AQ (Sambur) -- AF/TE (Manclark) memo, 8 April, 2002

Revisiting Quantitative Methods for Evaluating Training Programs for Systems Undergoing Operational Test (OT)

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About the Presentation...

- We shall revisit a method that can be used to quantitatively assess the efficacy of training programs

- The purpose is to provide a basis to state, within a prescribed degree of confidence, whether a change in fielded system performance can be attributed to technical issues or to training

- A classical, hypothesis-based approach, where operator “expert” or “trainee” -status is the independent variable, is described

Contents

The Problem

- *A system seems to perform well during Developmental Testing (DT) but when made operational, there is a notable decline in performance...* ***Is the problem with the system or with the training?***

Common Methods for Assessing Training

- Surveys, Questionnaires
- Interviews
- Focus Groups

These provide qualitative assessments that are not only based upon the respondents' experiences during OT, but also upon the aggregated experience, knowledge, feelings and attitudes of the respondents.

Drawbacks of Common Methods for Assessing Training

- Subjectivity
  - What one person's assessment of what is good/bad or acceptable/unacceptable is likely to vary based upon numerous things, including the background of the individual responding to the question
    - Compounding the problem is that survey question responses ranges are seldom "anchored" to something objective
- Internal Validity
  - Due to ambiguity or diverse definitions, interviewer or survey questions may not be measuring what the evaluator is interested in
    - Scientifically valid surveys are pre-tested and aligned in order to ensure validity.
- External Validity
  - The results of the sample survey may not be extendable to the larger population of all potential users of the system
- Bias
  - Some respondents may have a conscious or subconscious bias towards a given question response
- Apathy
  - Some respondents may resent the additional demand on their time of one more surveys. They may not use care in responding to the survey questions

Advantages of Common Methods

- Requires little or no additional testing because responses are based upon results obtained while collecting other measures

- Provides the opportunity for other relevant insights regarding the system or related DOTMLPF to be collected

DOTMLPF: Doctrine, Organizations, Training, Materiel, Leadership And Education, Personnel, And Facilities

Experiment Design Method for Determining the Efficacy of Training Programs

Hypothesis testing allows one to make an authoritative statement like :
"the training did not have a significant impact on the OT performance results"

- The ability gained through training is assigned as the independent variable
  - This is done using two test methods:
    - *Realistic Scenario Testing (RST)* performed by experts under conditions that replicate operational conditions to the greatest degree possible - - establishing a performance baseline
    - *Operational Testing (OT)* performed by actual end users in operational conditions or in a realistic operational exercise
- Experiment involves the test results of two groups, the experts performing RST and the end users performing OT
- Are the performance results of the experts during RST that much better than the real operators during OT?
- Validity of the results depends on the faithfulness with which the RST replicates the OT

Defining the Performance Metric

- The data elements that would normally be used to assess effectiveness of a system are used to assess training efficacy
- All variable types can be used
  - Nominal
    - Not associated with a value, just a label or categorization
  - Ordinal
    - Associated with a range of integer values such as with a Likert scale (i.e., 1 to 5 scale)
  - Ratio
    - Value can be any real number
- Performance metrics that are returned in averaged amounts need to be partitioned
  - i.e., instead of considering one test of 100 trials, ten averages of ten different trials are computed
    - The need to do this will soon be made plain

Governing Assumptions

- Systems used during OT and RST are essentially the same
- Experts are sufficiently experienced with the system
- RST environment and test conditions are sufficiently similar to OT condition
- Test subjects (if any) are similar between RST and OT
- Effects of operational stress during OT are negligible or somehow duplicated in RST

Statistical Significance

- Randomness effects all experimental results. Simply looking at the overall number of successes and failures in a test is an insufficient basis for conclusions. One must determine if the test results show *statistical significance*.

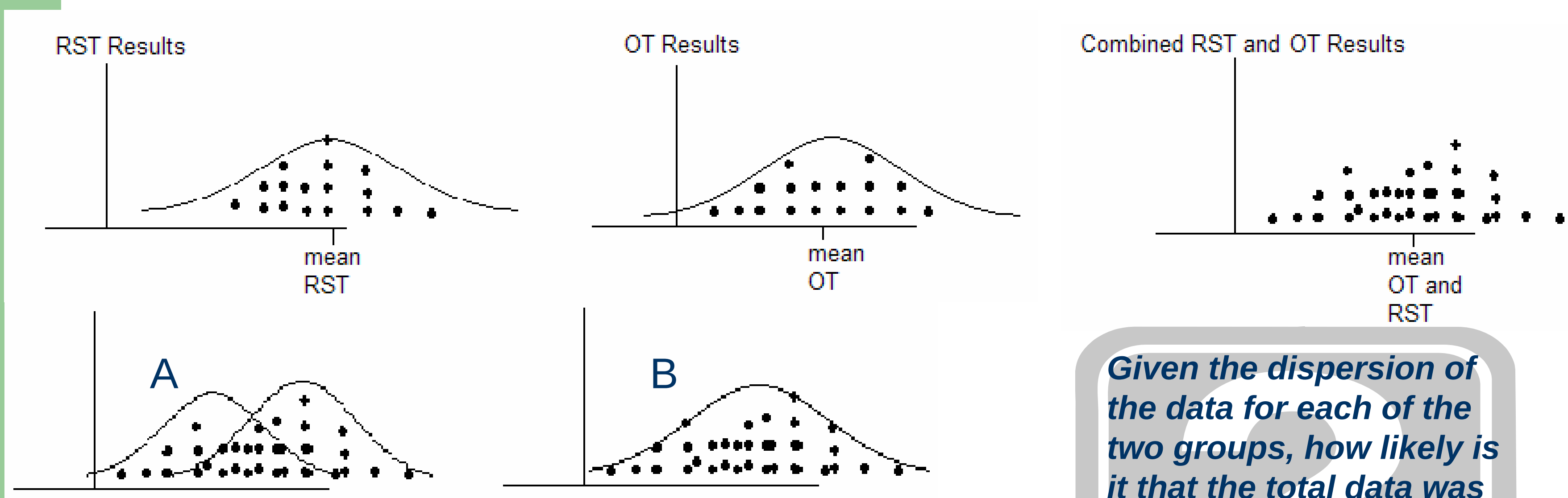
- Significance tests account for the possibility of a test result occurring due to chance alone. Various tests for significance have been developed and the correct test must be applied based upon the type of variables and the data distribution.

- Two of the most common tests for significance are the t-test, which is used for parametric (normally distributed) data; and the Chi-square test, which is used for nominal (categorical) data.

- If a significance test indicates that there is less than a 5% chance that the observed difference in results could be due only to chance, then usually a significant effect of the independent variable upon the results is noted.

Significance Calculations

- The statistical tests of Chi-Square (for nominal variables) and t-test (for ordinal, ratio, or averaged data) are available to test the following hypothesis:
  - “Training did not have a significant impact on the performance of the system during OT”
- The t-test will provide a measure of the likelihood that the performance averages taken from two test groups were taken from distributions with the same mean

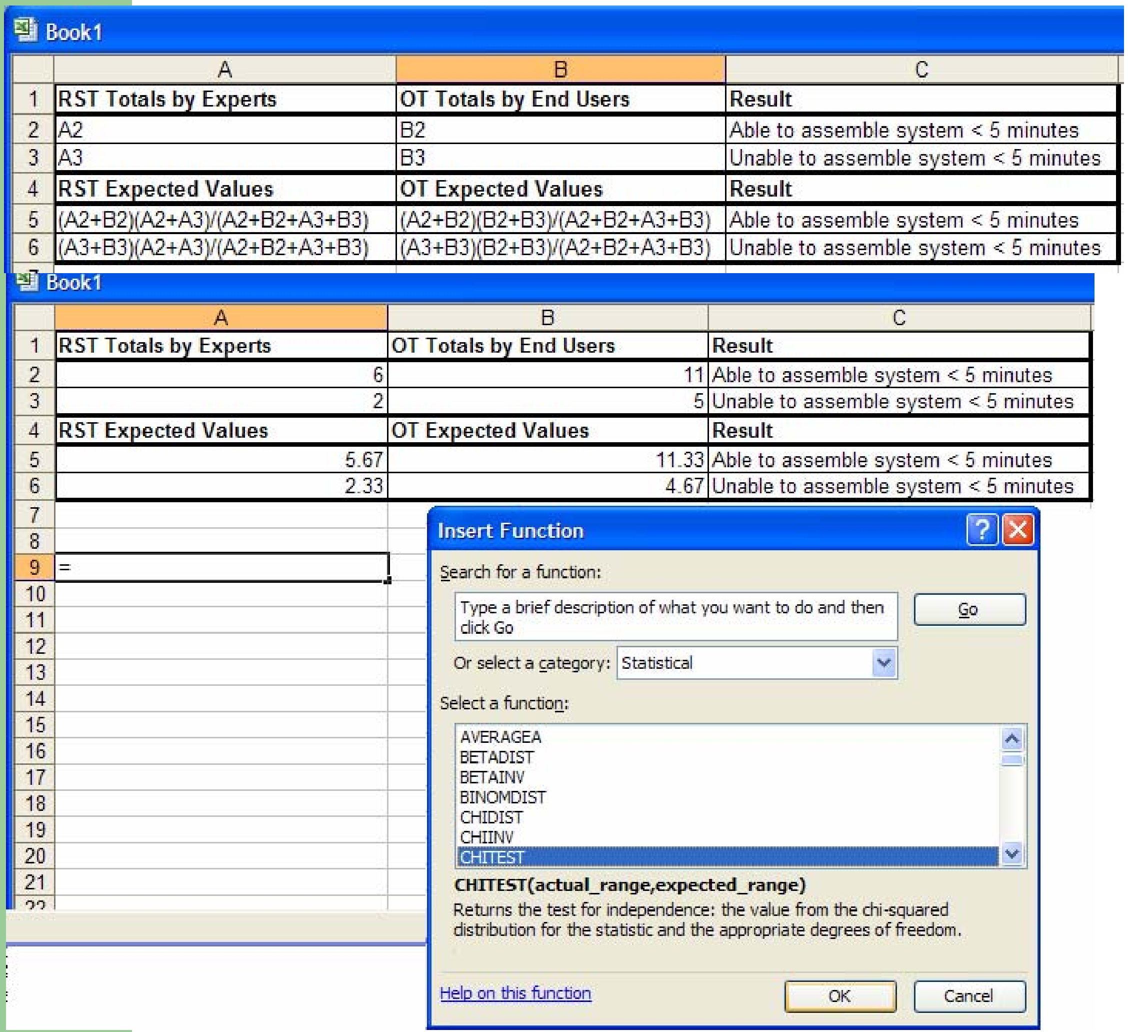


Given the dispersion of the data for each of the two groups, how likely is it that the total data was drawn from two separate distributions (A) or from a single distribution (B)?

Statistical Significance- Chi-Square [1]

- Applicable to nominal test result data
- Microsoft Excel and other spreadsheet programs can accommodate Chi-square calculations
- “Help files” provide usage and application instructions

Statistical Significance- Chi-Square [2]



1. Populate a table as shown. Note that columns A and B of rows 2 and 3 are the results of tests. The same columns in rows 5 and 6 are derived as shown from the test results above them
2. Use INSERT => FUNCTION and then select the STATISTICAL category. Select CHITEST
3. The wizard will allow you to select the cells of the test results (4 cells, A2,A3,B2,B3 in our example), and then the expected values that you have inserted, each, respectively
4. Clicking OK will return the result of the Chi-Square Test
5. The function returns the probability that the difference in performance between the RST and OT tests could have occurred due to chance as opposed to due to training effects (i.e. CHITEST value of 0.05 indicates a 5% probability that the difference in test results was not due to training issues [1,2])

1.) Based upon all governing assumptions

2.) Typically, 5% is the threshold (CHITEST >.05) where one would assume that the effects of training were not a significant factor in the difference in performance

Statistical Significance- t-Test [1]

- Applicable to normally distributed data such as those returned from survey results or laboratory measurements
- Microsoft Excel and other spreadsheet programs can also compute t-test results

Statistical Significance- t-Test [2]

Book1

	A	B	C
1		Kill Rates using new Targeting System	
2	Trial	RST Results by Experts	OT Results by End Users
3	1	0.8	0.8
4	2	0.85	0.83
5	3	0.82	0.84
6	4	0.9	0.9
7	5	0.92	0.88
8	6		0.9
9	7		0.92
10	8		0.91
11	9		0.8
12	10		0.78
13	11		0.8
14	12		0.9
15	13		0.92
16	14		0.76
17	15		0.77

- By entering "1" for the test type a paired t-test could be performed
- A paired t-test could be used in order to compare the ordered results of two data sets for one group, one before and one after training
- This would be a direct, single group test on the efficacy of a training program
- Such results could be of interest but would need to be interpreted carefully due to the possibility that the results of user "habituation" with the system is the causal agent and not training (internal validity)

1. Populate a table as shown. Note that the columns B and C might be populated with test results for individual test trials, averaged trial results for a particular test subject, or averaged survey results
2. Use INSERT => FUNCTION and then select the STATISTICAL category. Select TTEST
3. The wizard will allow you to select the cells of the RST test results (B3:B7 in our example), and then the OT results (C3:C17). The number of entries in each column need not be the same for our example
4. Enter a "2" for the number of tails to use for the test. This will account for the possibility that the end users over or under perform the experts
5. Enter "3" for the test type as there is no reason to assume that the variances of the two data samples will be the same
6. The function returns the probability that the difference in performance between the RST and OT tests could have occurred due to chance as opposed to due to training effects (i.e. TTEST value of 0.05 indicates a 5% probability that the difference in test results was not due to training issues *). If TTEST >0.05 assume training was not a performance issue

* Based upon all governing assumptions

Partitioning Technique for Averaged Performance Parameters (1 of 3)

Biometric System Performance Example

- Administrators of a fingerprint access control device are concerned as to whether the high False Accept Rate (FAR) of their system is due to poor system performance or might be a training related issue
- FAR is an aggregated performance parameter that is compiled from a large number of trials... In this case, fingerprint authentication transactions
- The methods described previously are not suitable for aggregated performance parameters because the data are not nominal, and the FAR is already an averaged value and thus, there would be no multiple trials to average and analyze.

Partitioning Technique for Averaged Performance Parameters (2 of 3)

- In order to employ the method, the two FAR tests (RST and OT) of 500 test subjects each are partitioned into twenty FAR tests (ten each RST and OT) of 50 test subjects each.
  - Every effort is made to ensure that the systems, the environment, and the test subject demographics are similar between RST and OT
  - Partitioning is employed in this case so the ten RST and OT FAR tests can be analyzed using a t-test
  - Partitioning can be by order, as in this example, or randomized
  - The number of test subjects and trials between the RST and OT tests need not be the same
  - FAR tests by their nature typically require a large number of test subjects
  - Overall system FAR calculations should be based upon all 500 trials for each test- - with no attempt being made to combine the individual FAR results into one representative one

Partitioning Technique for Averaged Performance Parameters (3 of 3)

- RST outperformed OT. The t-test indicated that there was an 28% likelihood that the RST and OT FAR test results could have been drawn from distributions with identical means
  - Because of uncontrollable factors such as stress during OT, and the relatively large likelihood that the performance difference was due to chance (28%), Analysts do not attribute the lapse in performance to training issues.
  - Technical solutions are emphasized over training ones

- The same data may be analyzed in an identical manner for different aggregated parameters (such as False Reject Rate)
  - The results should not considered to be confirmatory because the two analyses are not based upon independent data
  - If the <5% threshold for significance is met, then training problems would be indicated

Advantages and Drawbacks of Quantitative Methods for Evaluating Training

Advantages:

- The methods are objective in terms of data collection, in terms of analysis and in terms of interpretation of results
- The methods are associated with specific levels of confidence for conclusions

Drawbacks:

- Cost of conducting RST in addition to OT

Conclusions

- Survey methods can be supplemented, confirmed, or refuted using quantitative methods

- Method for attributing lapses of performance to either system or training was discussed
  - Experimental design using RST and OT establishes training as the independent variable
  - Nominal performance metric (Chi-square)
  - Ordinal and ratio metrics (t-test)
  - Aggregated performance metric (t-test)

- Other applications for using quantitative methods for analyzing training programs include:
  - Side by side comparison of different training approaches
  - Pre and Post training analyses
  - Analysis of effectiveness of modifications to training programs

Thank you!

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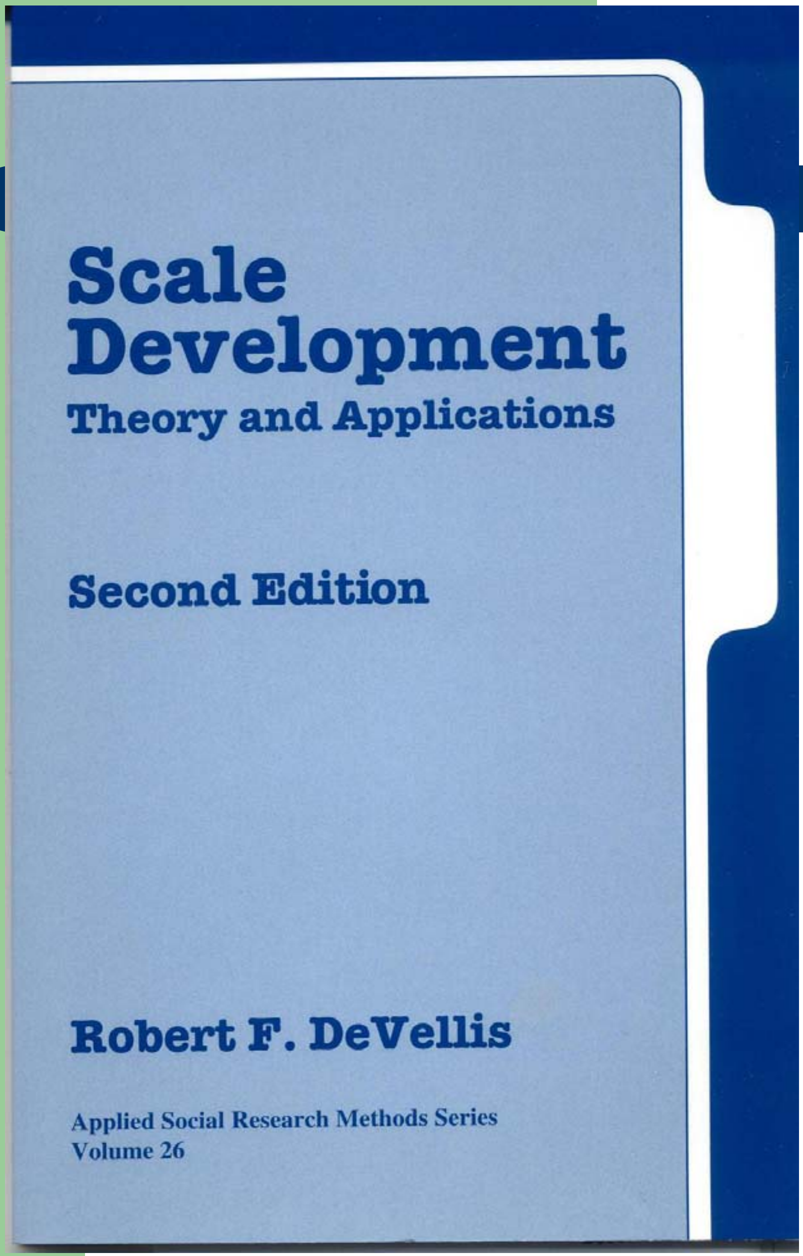
Back-up



An excellent reference describing how to apply Likert type scale survey techniques correctly

Reliability-based Design, Development and Sustainment

NDIA's 2007 T&E Conference:

T&E in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems

Dr. Anne Hillegas and Dr. Justin Wu, ARA
15 March 2007

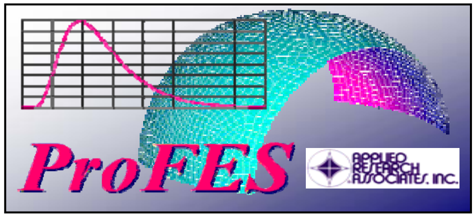
APPLIED RESEARCH ASSOCIATES, INC.
An Employee-Owned Company

Briefing Overview

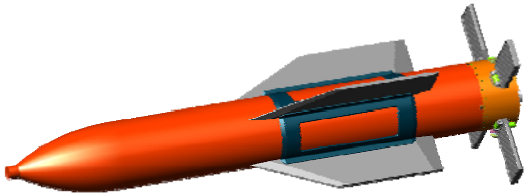
- Description of reliability-based methods
- Applications and results
- Implications of reliability-based methods for T&E
- Challenges
- Path ahead

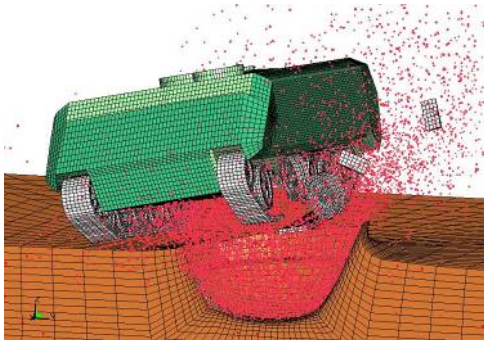
ARA BUSINESS AREAS

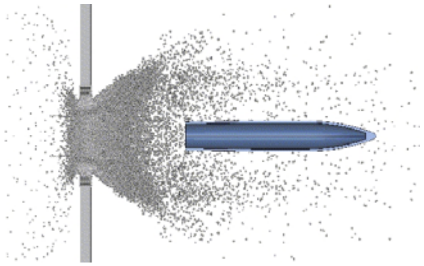
- National Defense
- Transportation
- Security Risk & Disaster Management
- Geotechnical & Environmental Technologies
- Computer Software & Supporting Technologies



Probabilistic Function Evaluation System







Introduction

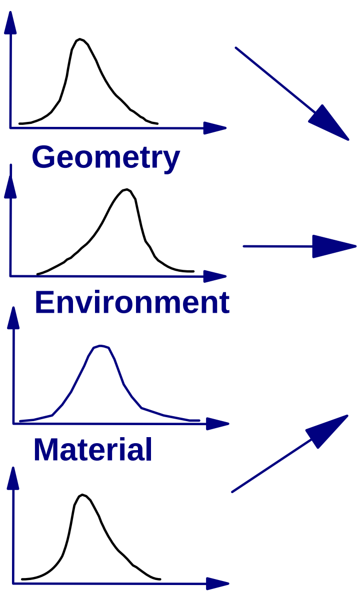
- Reliability-based methods are those that
  - Use the probability of failure as a criterion in the design process
- These methods contribute to suitability, effectiveness and sustainability by
  - Improving system performance
  - Increasing operational readiness
  - Reducing unnecessary intervention or maintenance
  - Managing spare parts inventories
  - Reducing technical and operational risk
- Other benefits of these methods
  - Provide predicted performance across a range of metrics
  - Support decision-makers by highlighting trade-offs in performance and RAM

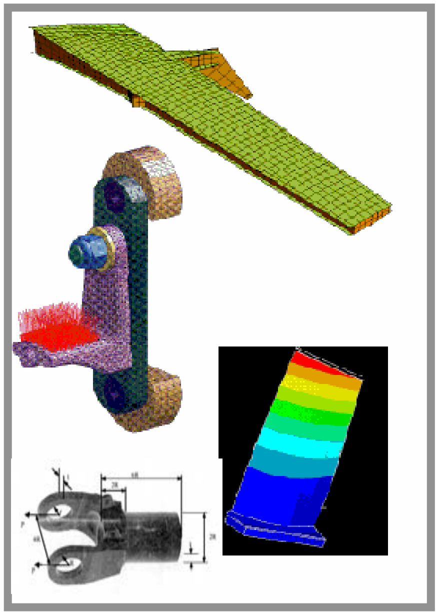
The “Magic” behind the Methods

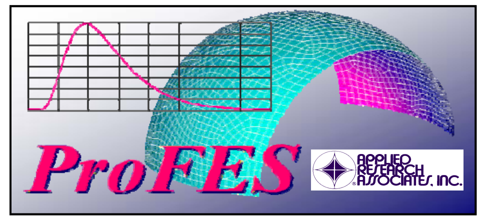
- These methods involve
  - Applying probability distributions to uncertainties
  - Using physics-based modeling to assess the impact of these uncertain factors on system performance
  - Balancing system design features and inspection intervals against risk

Physics-based Probabilistic Analysis

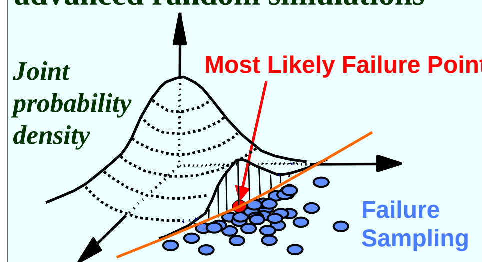
PRObabilistic Function Evaluation System







Uncertainty analysis based on *fast probability integration* and advanced random simulations



Compute:
- Risk
- Reliability
- Reliability sensitivities
- Response probability distributions
- Failure samples for maintenance simulation

Optimize:
- Risk and Reliability
- Maintenance Plan
- Test Plan

Model Uncertainties and Variability

Develop High Fidelity Computational Models

Apply State-of-the-Art probabilistic methods

Focus on "Weakest Links" and Most Likely Causes for Failures

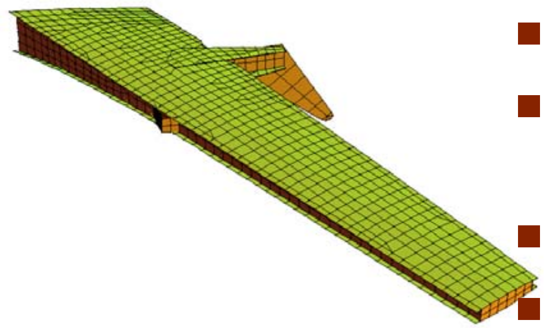
Reliability-based Methods that support Suitability, Effectiveness and Sustainability

- Reliability-based multidisciplinary optimization (RBMDO)
- Reliability-based damage tolerance (RBDT)

Reliability-based Multi-disciplinary Optimization (RBMDO)

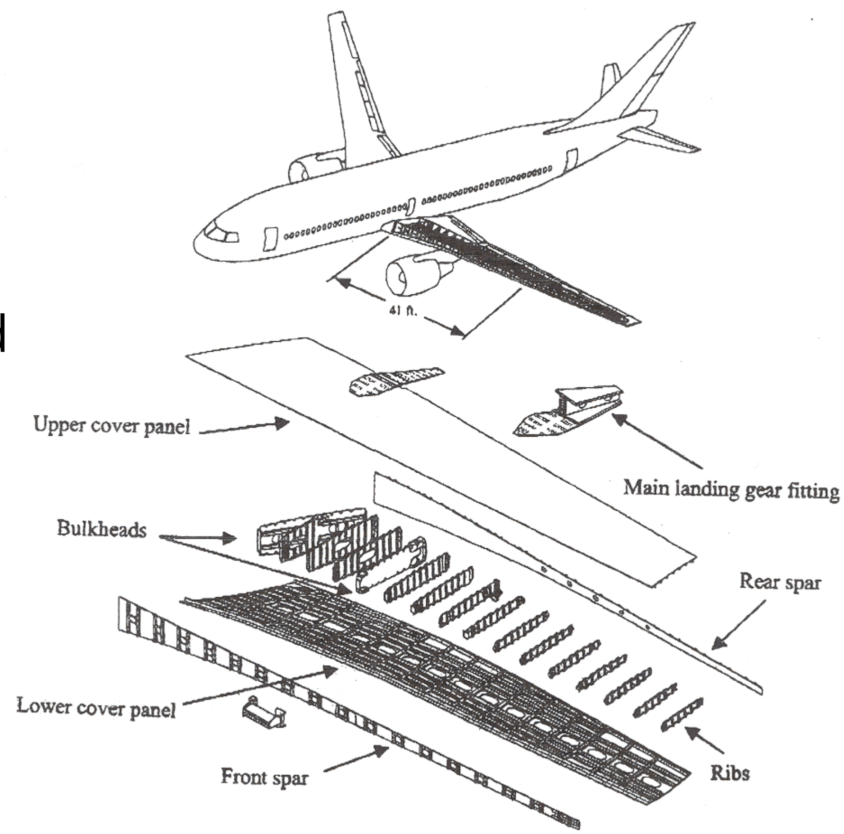
- Optimizes performance subject to multiple reliability-based constraints
- Incorporates multi-disciplinary objectives/models (e.g., payload, aerodynamics, shape parameters, weight,…)
- Accomplishes higher performance over independent optimization of each discipline

RBMDO Application – Aircraft Wing Design

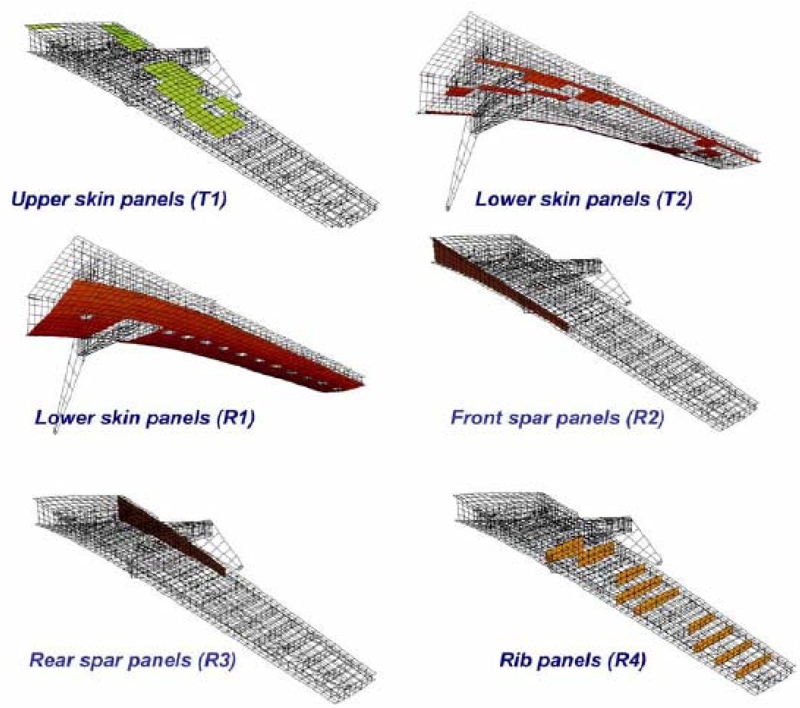


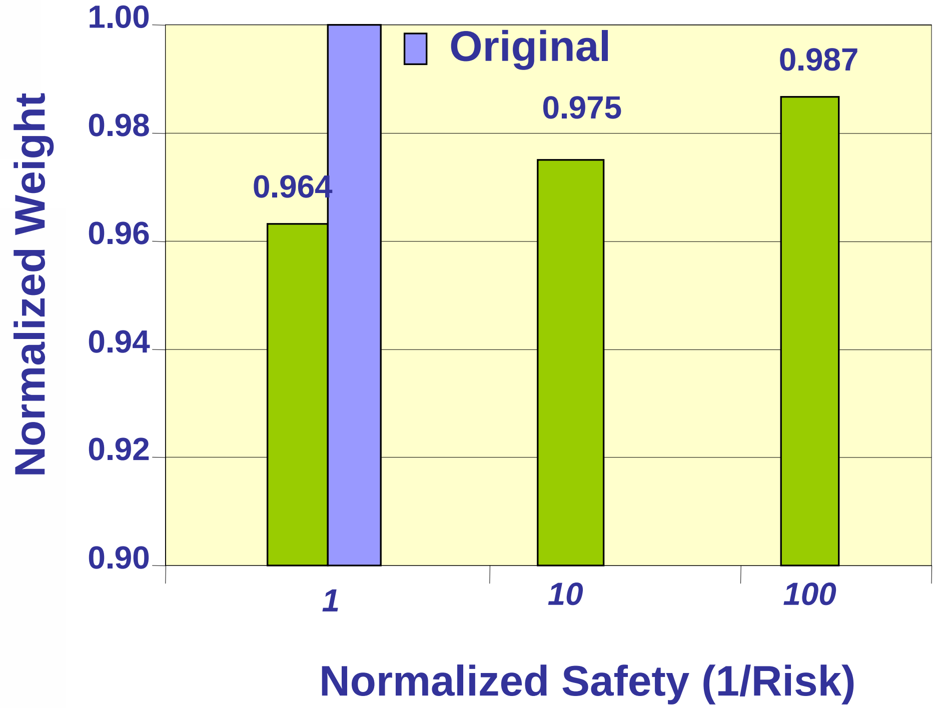
- 3804 finite element nodes
- 3770 finite elements (2222 shells + 1548 beams)
- 22 material properties
- 47 shell element properties

- NASTRAN model of Advanced Composite Technology (ACT) wing
- Baseline aircraft: proposed 190-passenger, two-class, transport aircraft
- Critical Design conditions derived from DC-10-10 and MD-90-30



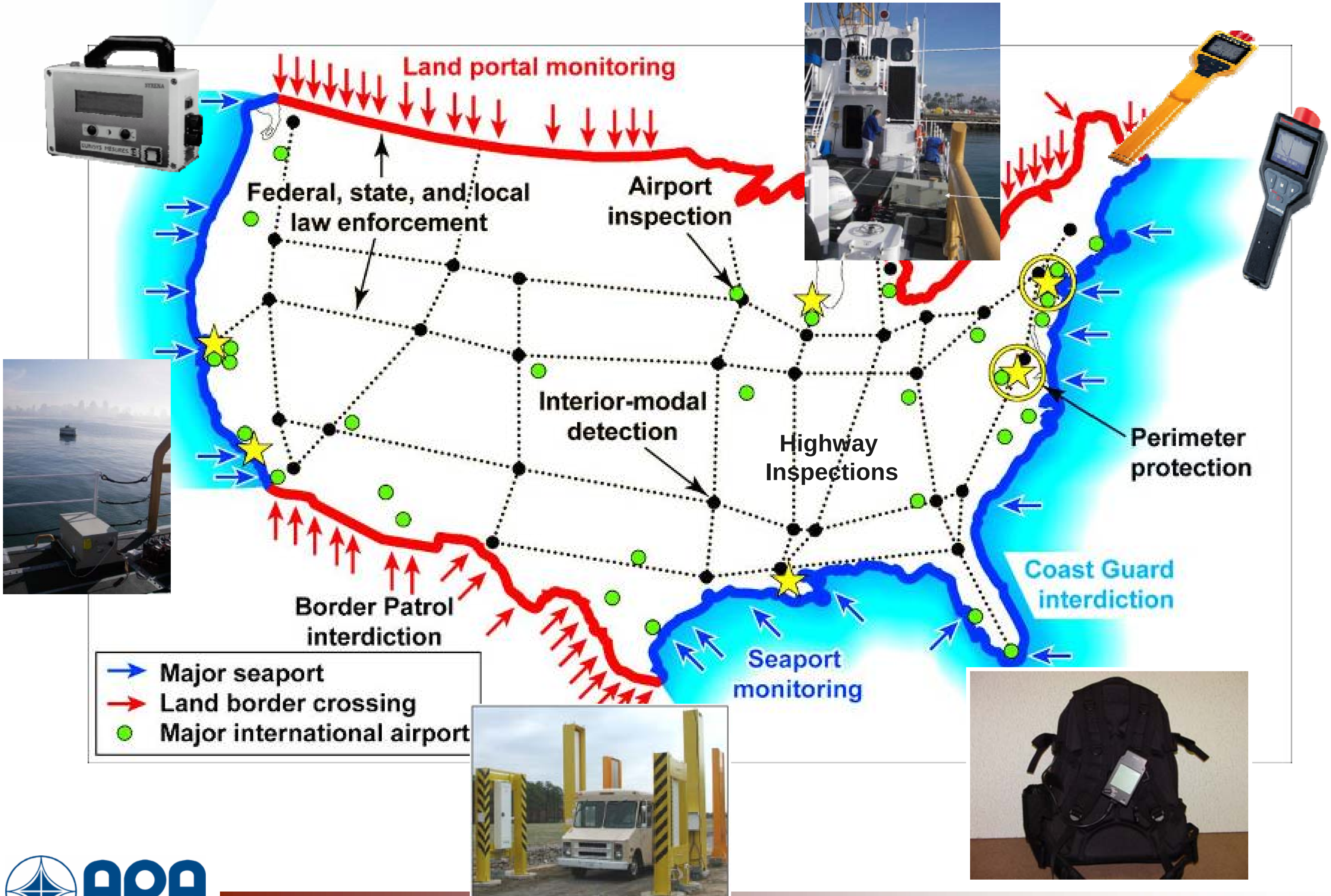
Performance-based objective and reliability-based constraints





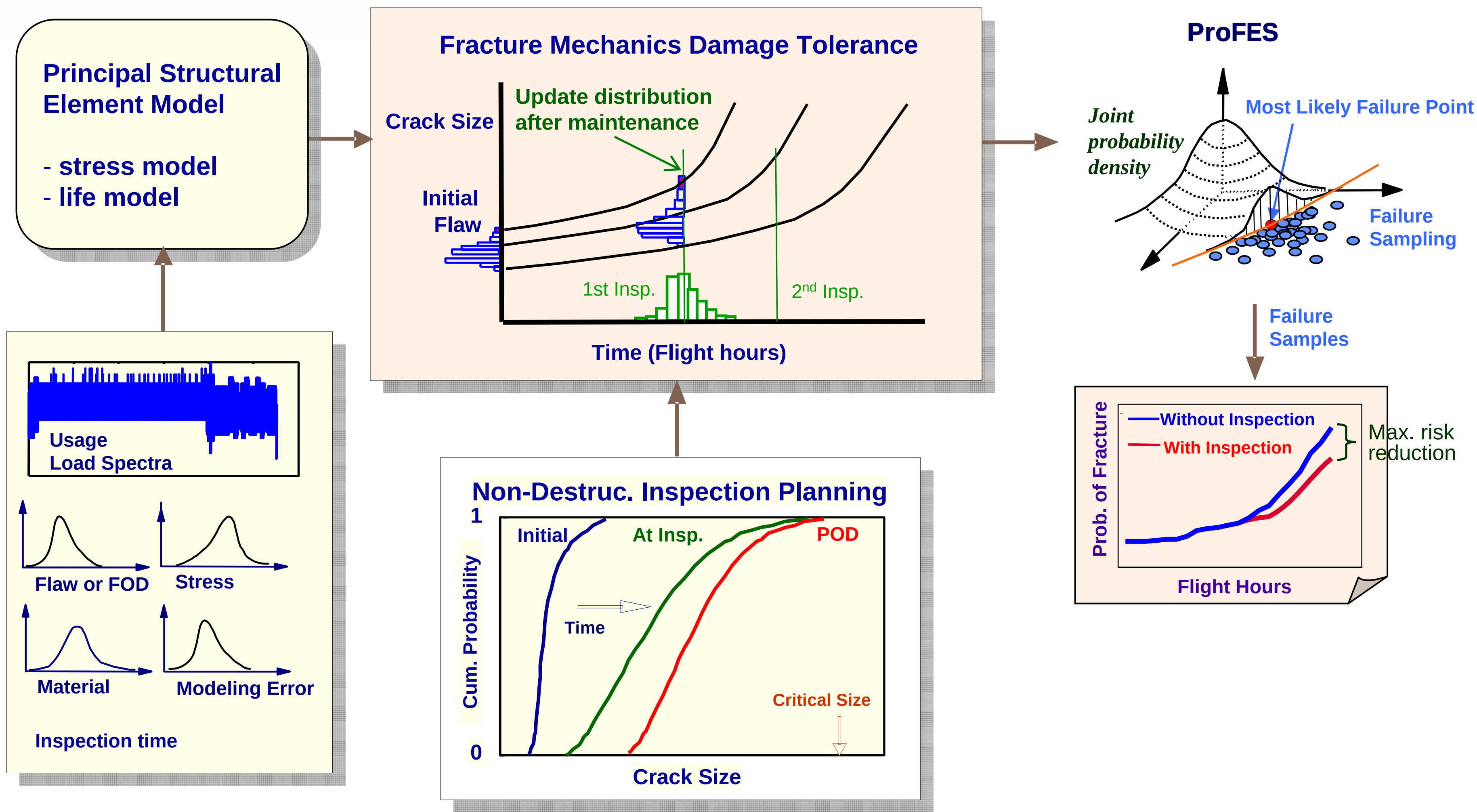
Weight is reduced while reliability is improved

Another Application – Radiation Detector Sustainment



Reliability-Based Damage Tolerance (RBDT) Framework

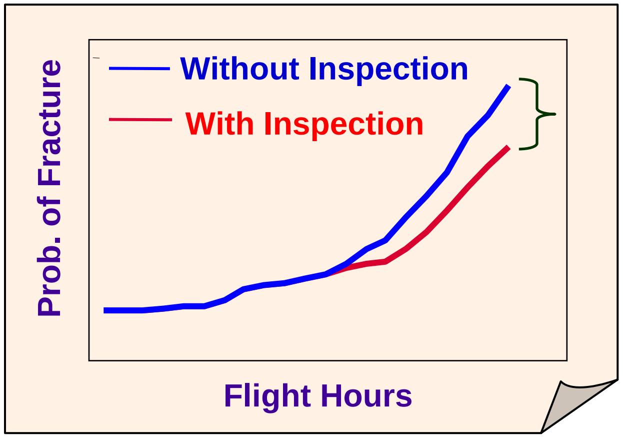
Fully Integrated Finite Element stress, Fracture Mechanics life and ProFES analyses



Reliability-Based Damage Tolerance (RBDT) Methodology for Rotorcraft Structures

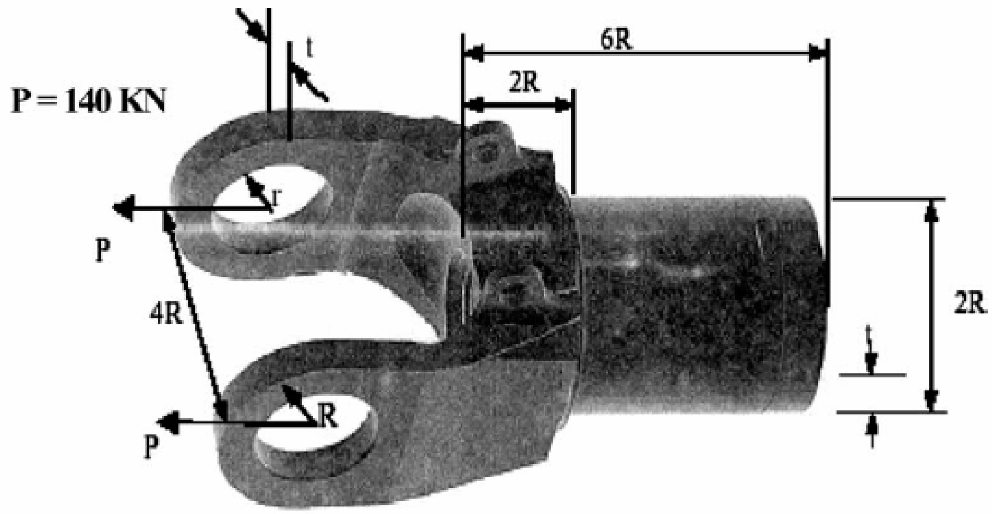
- Project sponsored by FAA
- Critical structures must maintain very small probability of failure
- Supplement current “safe-life” design approach (which tends to be too conservative)
- Systematically treat variability/uncertainty in:
  - usage, load, flaw, material, geometry, modeling error, defect detection capability
- Maintenance planning for:
  - Non-Destructive Inspection, inspection frequencies, repair/replacement
- Has wide applicability to structures with material or manufacturing flaws
  - Select appropriate NDI interval
  - Optimize sustainment strategies

	Deterministic	Probabilistic
Underlying Principles	Bounds or Safety Factors	Probability & confidence
Flaw/Defect size	A given crack size	Probabilistic distribution
Flaw Existence	Certain (Safe-Life)	0 < Probability < 1
Inspection Schedule	Life/No. of inspections	Optimized schedules for max. risk reduction
Safety Measure	Safety margin	Reliability
Other Variables	Bounds or Safety Factors	Distributions



Max. risk reduction

RBDT Application -- Rotorcraft Spindle Lug Model



Reference R = 0.25m, Thickness = 67 mm, Initial flaw size = 0.4 mm

Random variables for the lug model

	Distribution	Mean	SD	Cov (%)
Thickness, t (mm)	LN	28	0.14	0.50
Max. load (N)	LN	145000	10000	6.9
Initial flaw size (mm)	User-defined	0.074	0.0224	30.2
Delta K_{th}	LN	48	4	8.33
Life scatter	LN	1	0.1	10.0

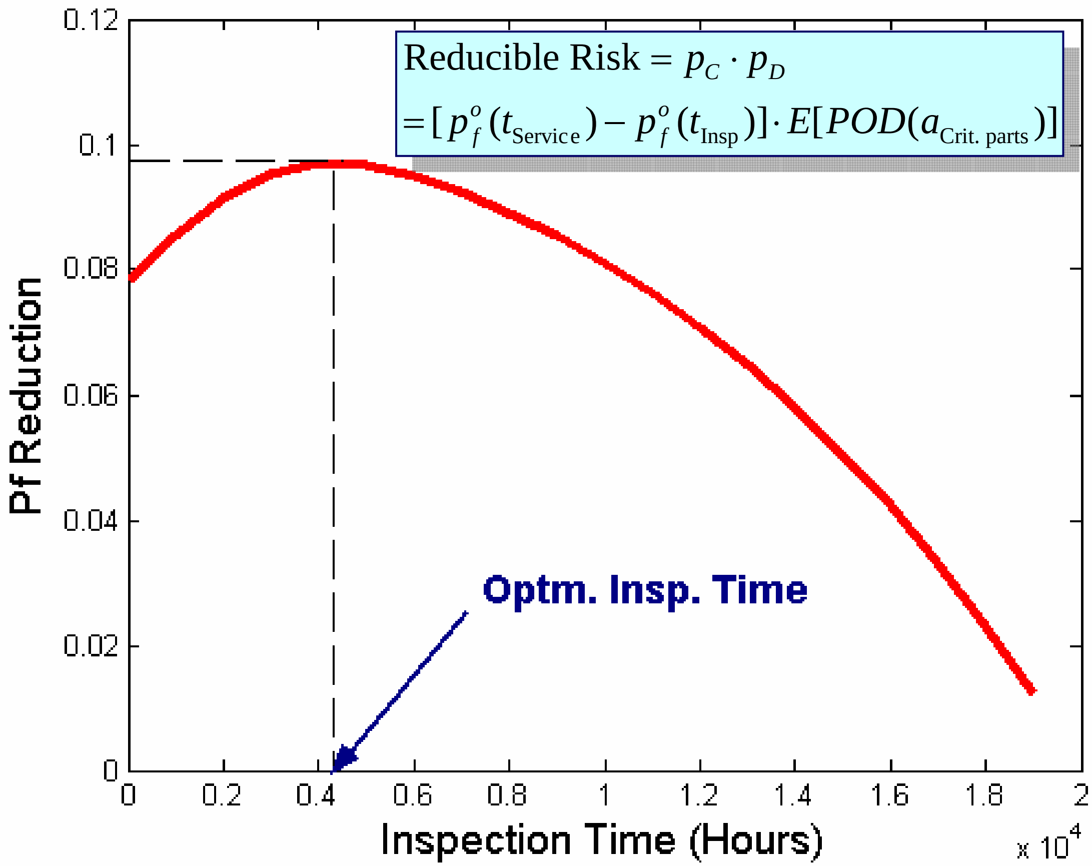
Goal – Optimize inspection schedule to minimize risk

RBDT Yields Optimal Inspection Schedule

Systematic approach for probabilistic fracture mechanics damage tolerance analysis with maintenance planning under various uncertainties

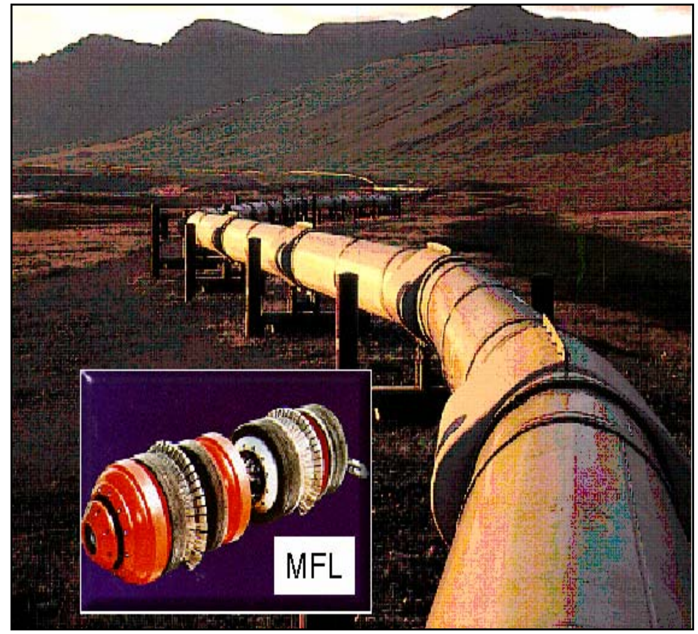
Stage 1: compute risk without inspection

Stage 2: compute risk with inspection by simulating inspection and maintenance effects using the samples generated from the Stage 1 failure domain



Reliability-based Damage Tolerance Application Pipeline Maintenance Optimization

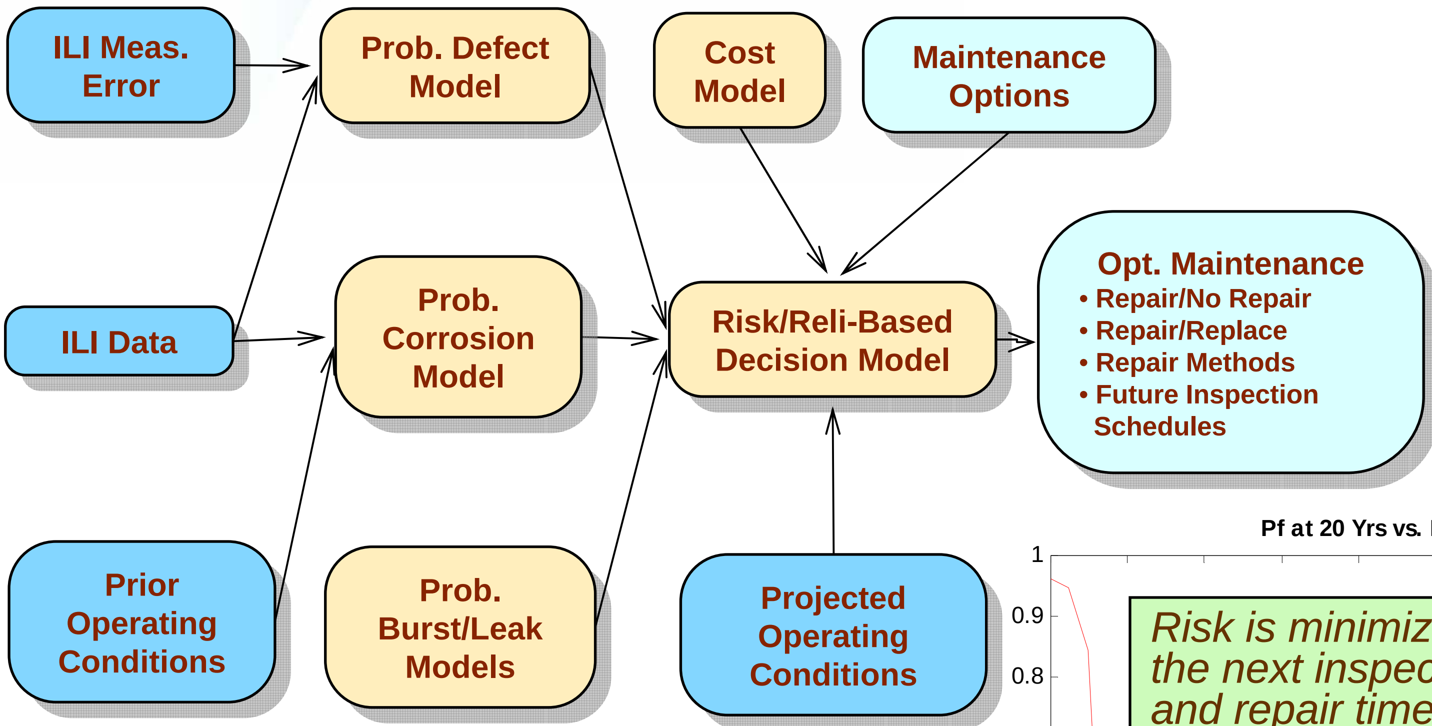
- Corrosive environments cause metal losses
- Two major failure modes with uncertainties
  - Burst can cause a high consequence but is less likely to occur
  - Leak has a low consequence but is more likely to occur
- In-line inspection devices can detect significant defects
- Options to maintain integrity at different risk/cost:
  - Defect monitoring using high resolution ILI devices (cost issue)
  - Repair/replace sections (cost issue)
  - Reduce operating pressure (production loss)
  - Corrosion mitigation (cost issue)
- Objective
  - Develop maintenance optimization software using ILI data and probabilistic failure and cost models

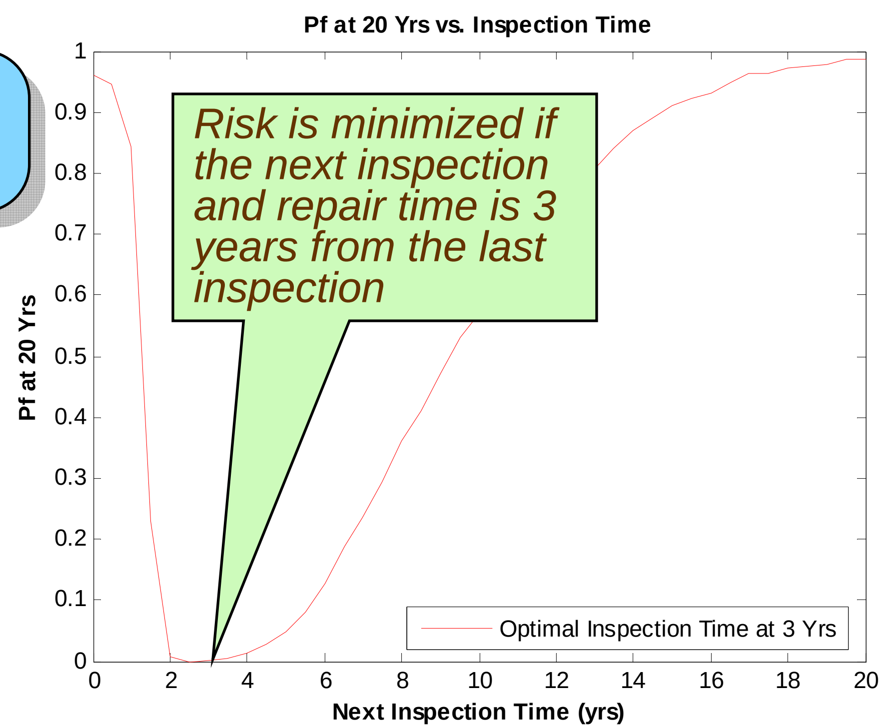


In Line Inspection

Magnetic Flux Leakage and other ILI devices can travel through pipelines to detect metal losses

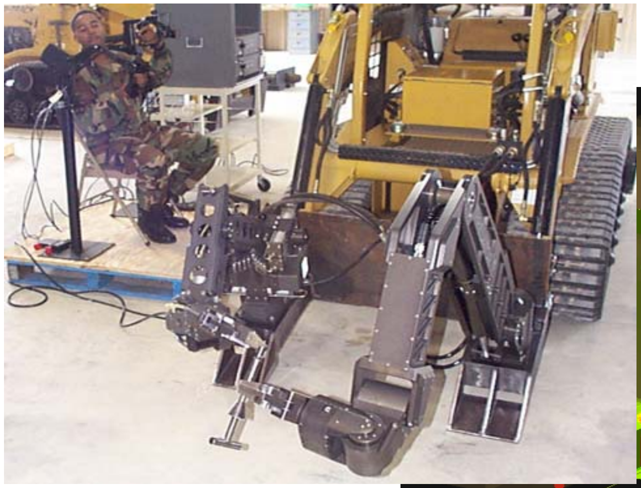
Pipeline Maintenance Example

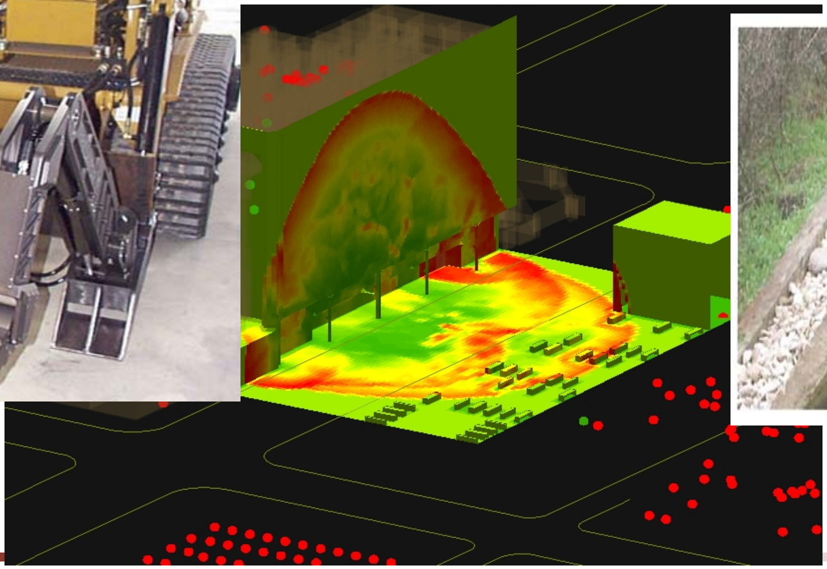




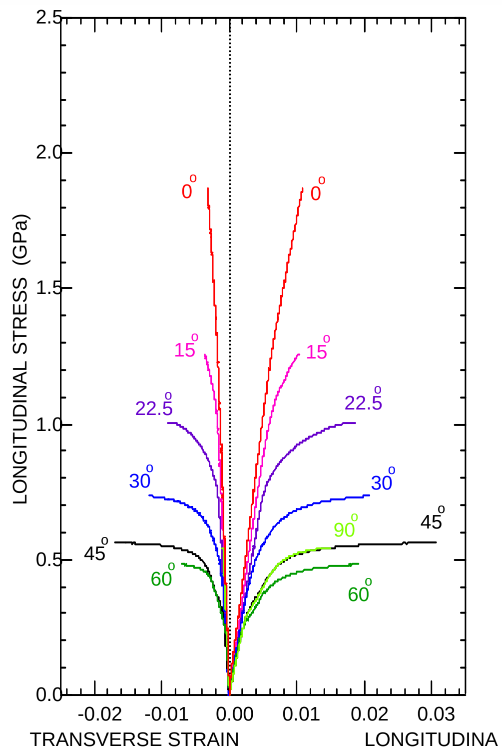
Pipeline Maintenance Optimization Methodology

Another Application – Robotic/Unmanned Systems Design





Implications for T&E



Experimental data

Material Testing

Material Constitutive Modeling

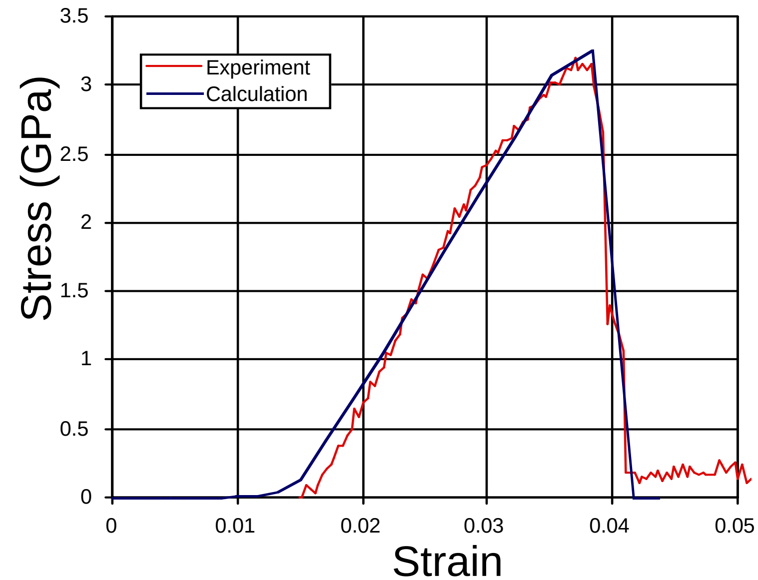
Component Analyses

Subassembly Analyses

Global Analyses

Observables

Validation Tests



Building block approach requires testing at all levels

Wrap-up

- Accomplishments
  - Tools for taking a reliability-based approach to design and sustainment that can result in cost savings and risk reduction
  - Traceable predictions of reliability and performance changes
  - Computationally fast and efficient methods
- Challenges
  - Scalability of approach
  - Understanding material failure properties
  - Cascade of variable and interrelationships
    - Non-unitized structures
  - “User friendliness”
    - Enable use by decision-makers

Path Ahead

- Mature/prove methods for specifying probability distributions
  - ARA's Klein Associates Division (cognitive scientists)
- Refine the understanding of the impact and interaction of the uncontrollable random variables
- Accelerate collection of data to inform physics-based models
- Continue to evolve cost- and time-effective testing approaches for verifying reliability

Hazard Assessment Testing of the SM-3 Block IA Missile

Presentation for the

NDIA 23rd Annual National Test and Evaluation Conference

13 March 2007

Dave Houchins

Dahlgren Division, Naval Surface Warfare Center

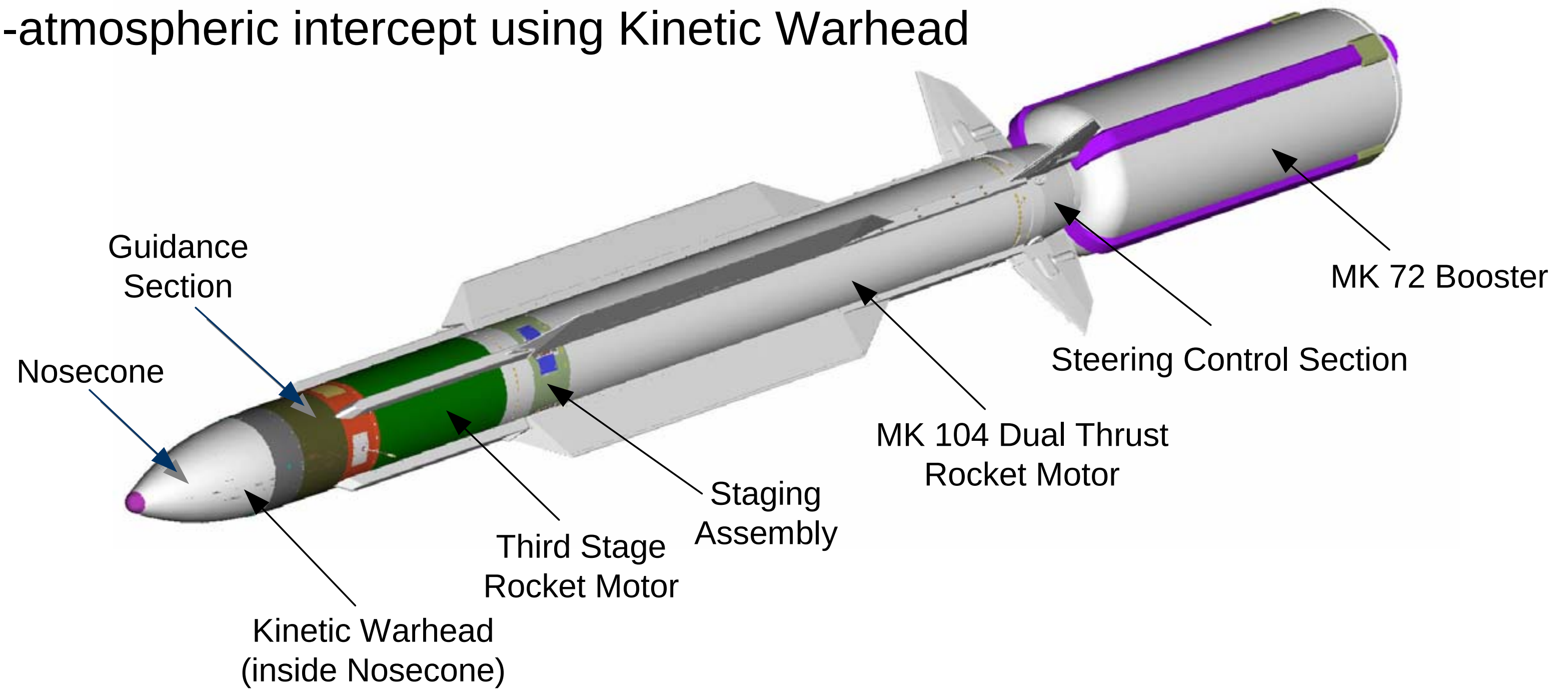
Test & Evaluation Division (Code G60)

Outline

- Description of SM-3 Block IA missile
- Hazard Assessment Test Program
- Test methodologies
- Summary of results
- Lessons-learned

SM-3 Block IA Missile

- Sea-based component of the Ballistic Missile Defense system
- Launched from Vertical Launching System of DDG-class ships
  - Approximately 22 ft length x 13.5 in diameter
    - MK 72 booster ~21 in diameter
  - Contains ~2065 lbm propellant
  - Designed for MK 21 MOD 2 VLS canister
    - Total mass of all-up round ~6300 lbm (i.e., missile and canister)
- Exo-atmospheric intercept using Kinetic Warhead

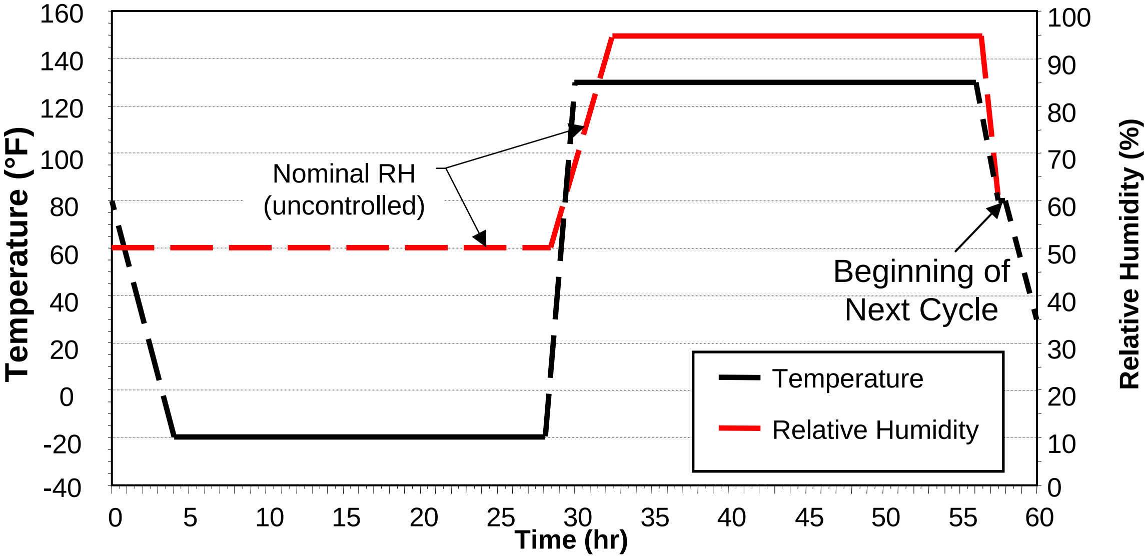


Hazard Assessment Test Program for SM-3

	1999 SM-3 Block 0	2004 SM-3 Block I	2005/2006 SM-3 Block IA
Environmental Tests (encanistered missile)	28-Day Temperature & Humidity	28-Day Temperature & Humidity	28-Day Temperature & Humidity
	Transportation Vibration Shipboard Vibration Launch Shock	Transportation Vibration Shipboard Vibration	Transportation Vibration Shipboard Vibration
	4-Day Temperature & Humidity	4-Day Temperature & Humidity	4-Day Temperature & Humidity
	40-ft Drop Aft-end down	40-ft Drop Horizontal	Near Miss Shock
			Functional Tests of Components
Insensitive Munitions Tests (individual sections)	Fast Cook-off Third Stage Rocket Motor Kinetic Warhead	Slow Cook-off Third Stage Rocket Motor Kinetic Warhead	Bullet Impact Third Stage Rocket Motor Kinetic Warhead
			Fragment Impact Third Stage Rocket Motor Kinetic Warhead
			Fast Cook-off Third Stage Rocket Motor

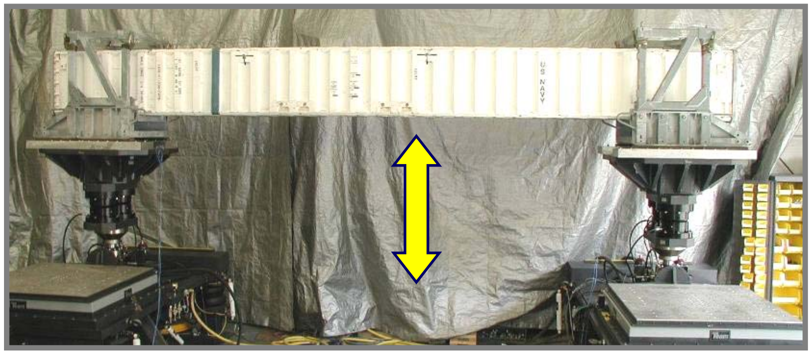
28-Day / 4-Day Temperature and Humidity (T&H) Test Method

- Encanistered missile cycled between hot/humid and cold environments
  - Conditions based on environmental profile for logistics life-cycle
    - +130F with 95% RH for hot/humid environment
    - -20F for cold environment
  - 1 cycle includes 24-hr (min) exposure to each environment
- Tests conducted using programmable environmental chamber
- Test methods identical except for duration
  - 14 cycles for 28-day T&H; 2 cycles for 4-day T&H

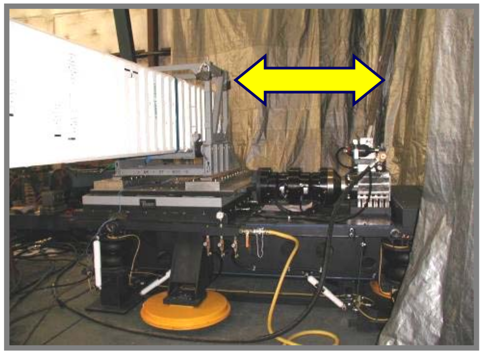


Transportation Vibration Test Method

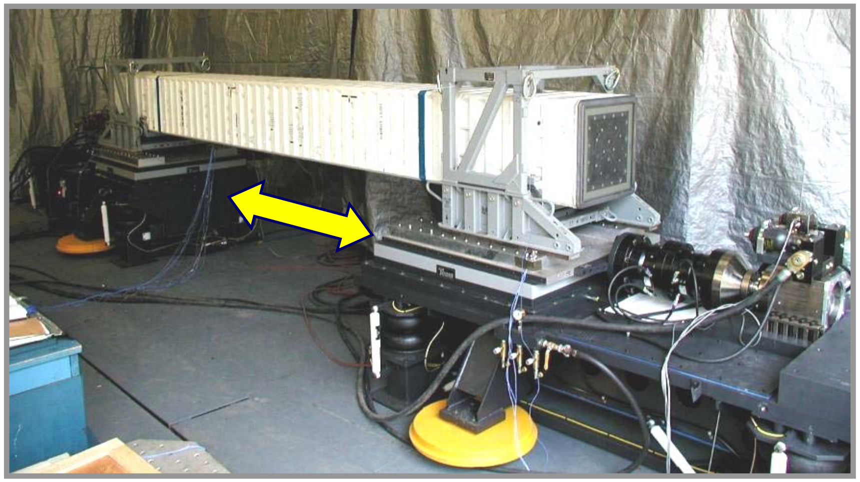
- Encanistered missile subjected to random vibration IAW MIL-STD-810
  - Simulate transportation by truck over improved roads
  - Input applied through 3 orthogonal axes; 1 axis at a time
  - 3 hr/axis duration to simulate 3000 miles over-the-road transport
- 2 hydraulic actuators used to provide input at each PHS&T skid



Vertical Axis

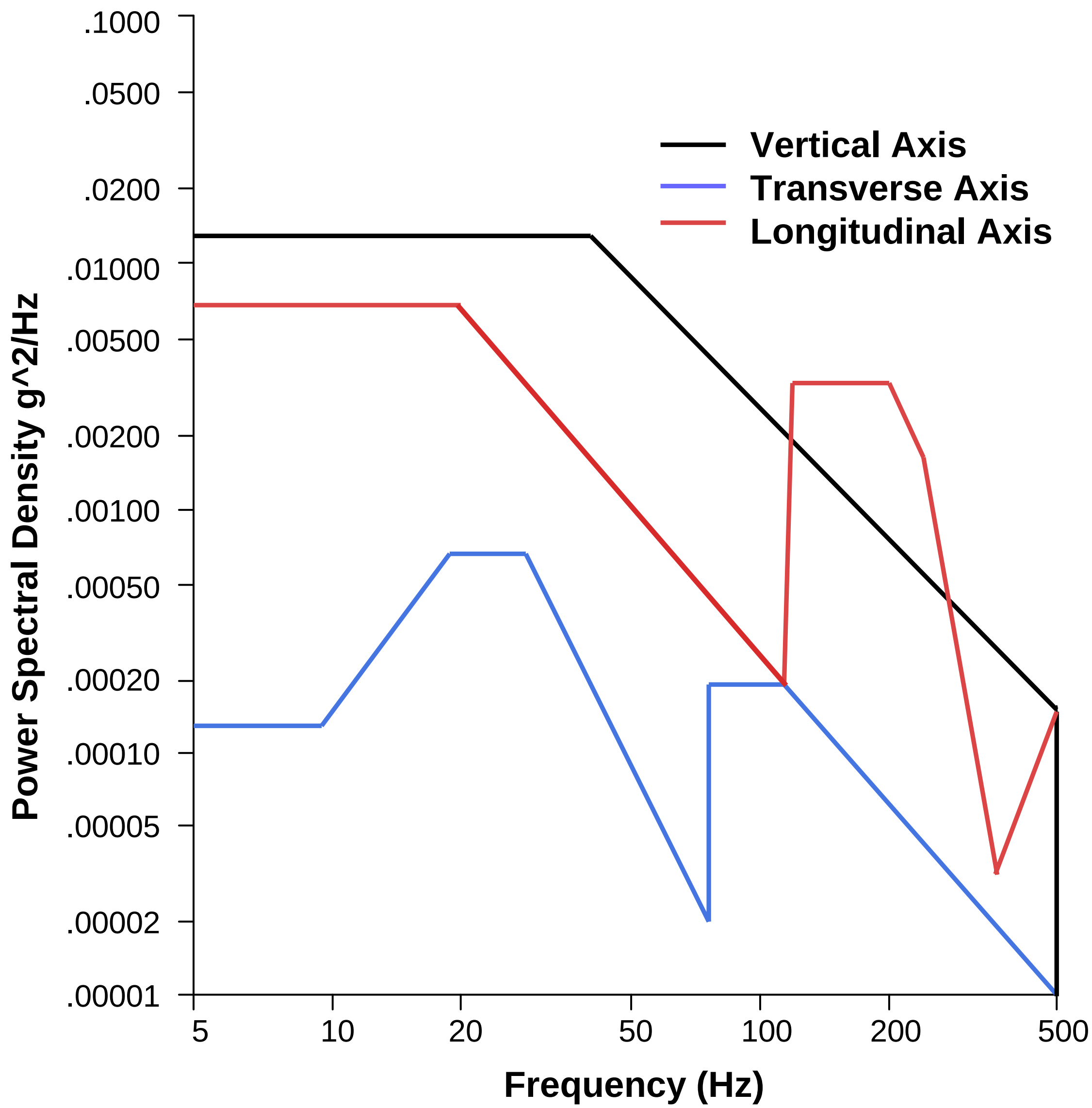


Transverse Axis



Longitudinal Axis

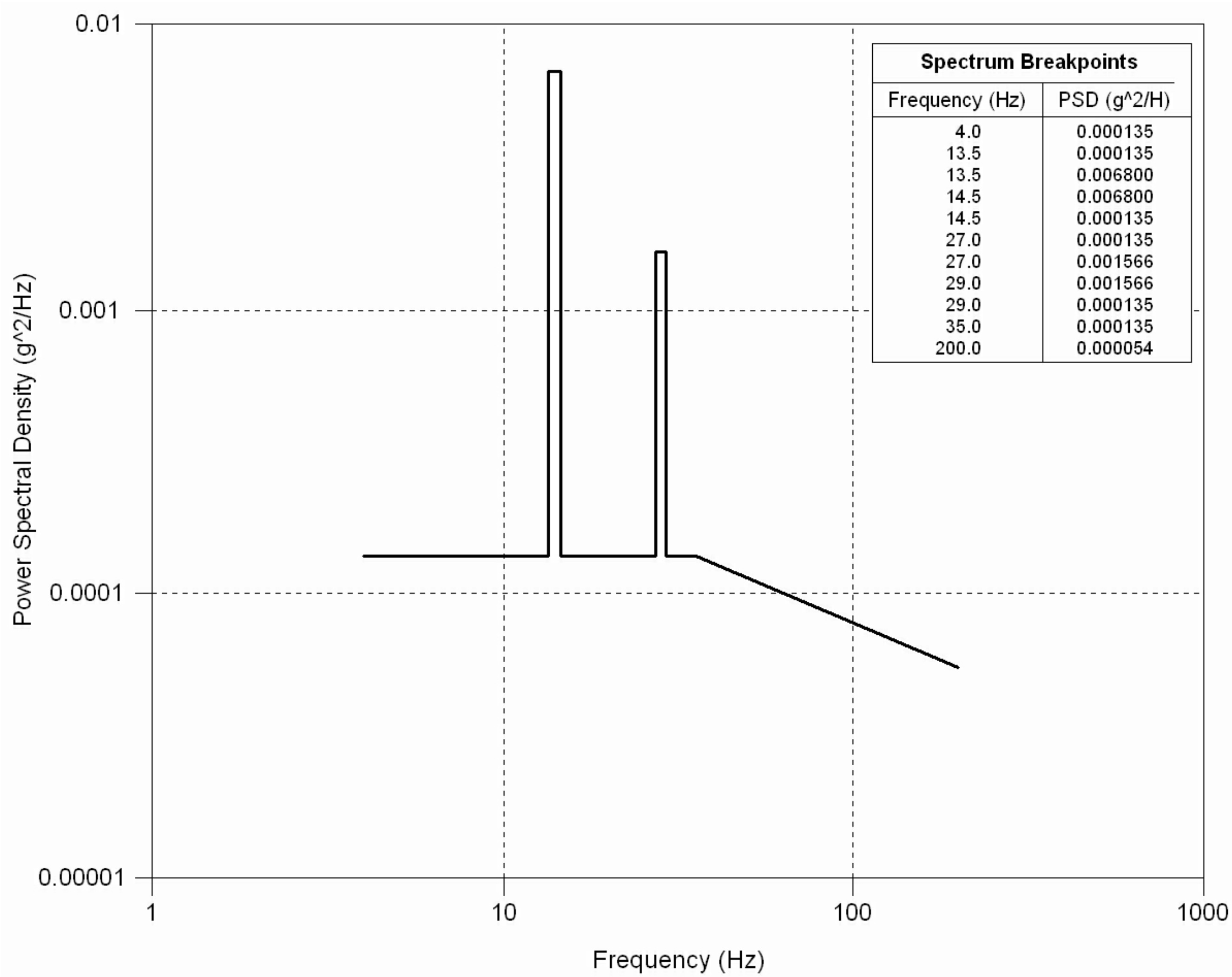
Transportation Vibration Input Profile



Shipboard Vibration Test Method

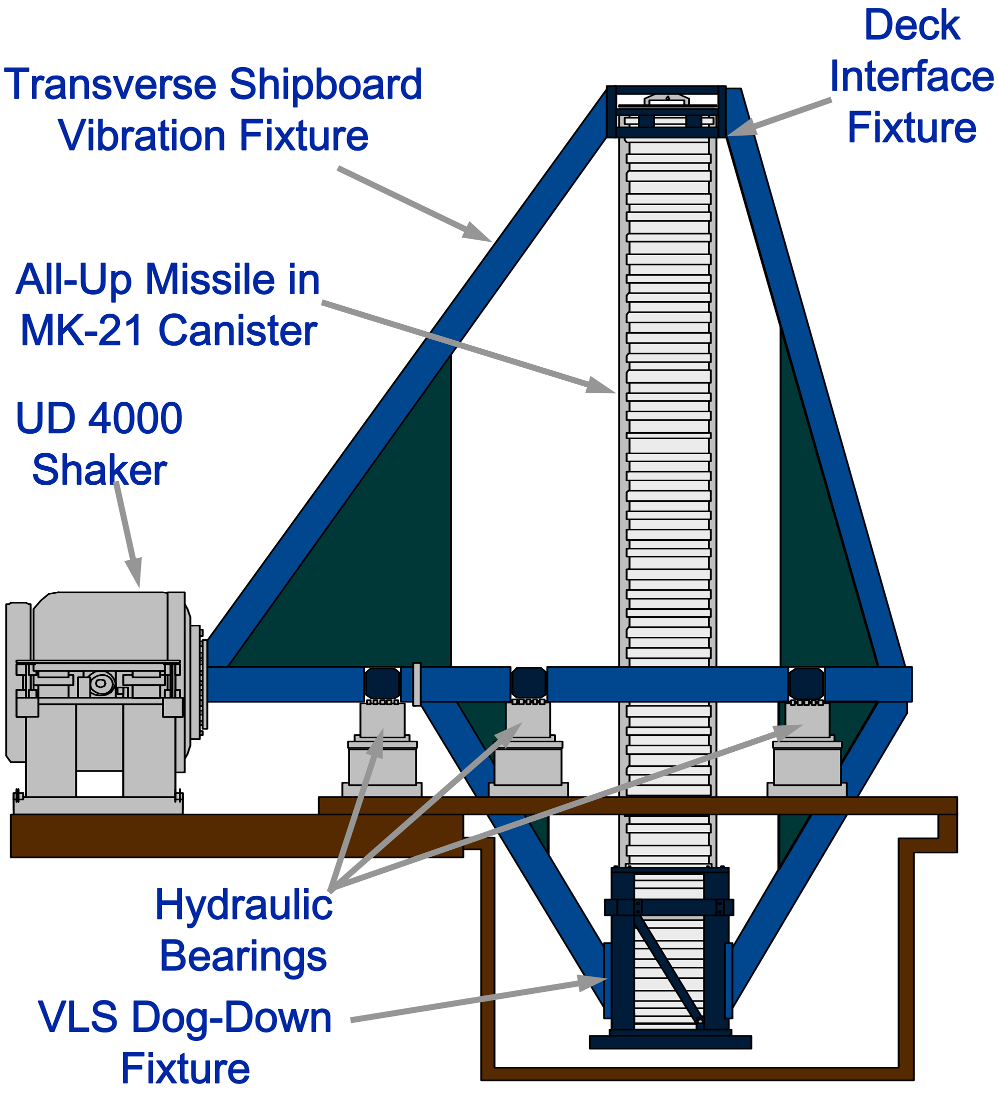
- Encanistered missile subjected to random vibration to simulate shipboard environment
  - Input profile and duration based on shipboard measurements in VLS cells
    - 4 – 200 Hz frequency range
    - Input spectrum encompasses full range of ship speeds and sea states
    - 39-hr/axis to simulate anticipated deployment durations
  - Input applied through 3 orthogonal axes; 1 axis at a time
- System-specific tailored test requiring approval from NAVSEA 05T
  - Most systems tested IAW MIL-STD-167
    - Sinusoidal vibration across 5 – 50 Hz frequency range
- Accomplished using UD-4000 electrodynamic shaker
  - Special fixtures used to provide input at correct interfaces with canister

Shipboard Vibration Input Spectrum

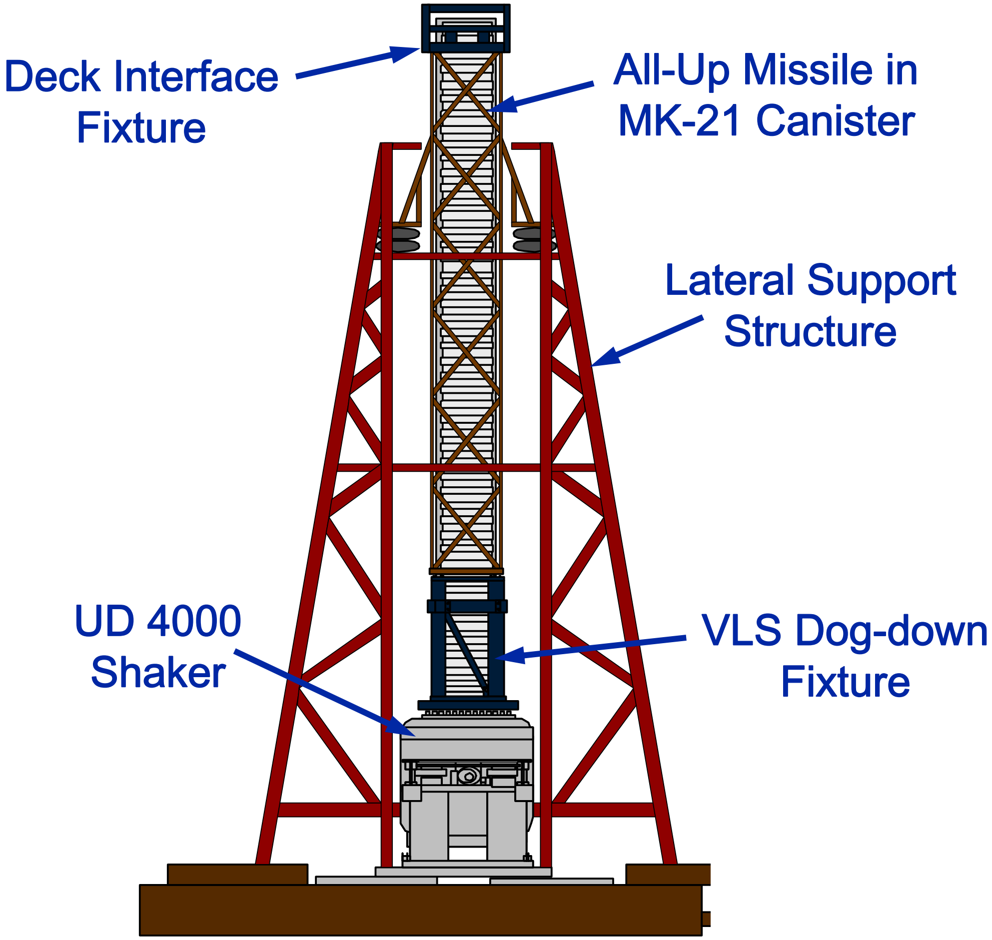


Frequency (Hz)	PSD (g^2/H)
4.0	0.000135
13.5	0.000135
13.5	0.006800
14.5	0.006800
14.5	0.000135
27.0	0.000135
27.0	0.001566
29.0	0.001566
29.0	0.000135
35.0	0.000135
200.0	0.000054

Shipboard Vibration Test Setup (Transverse Axis)



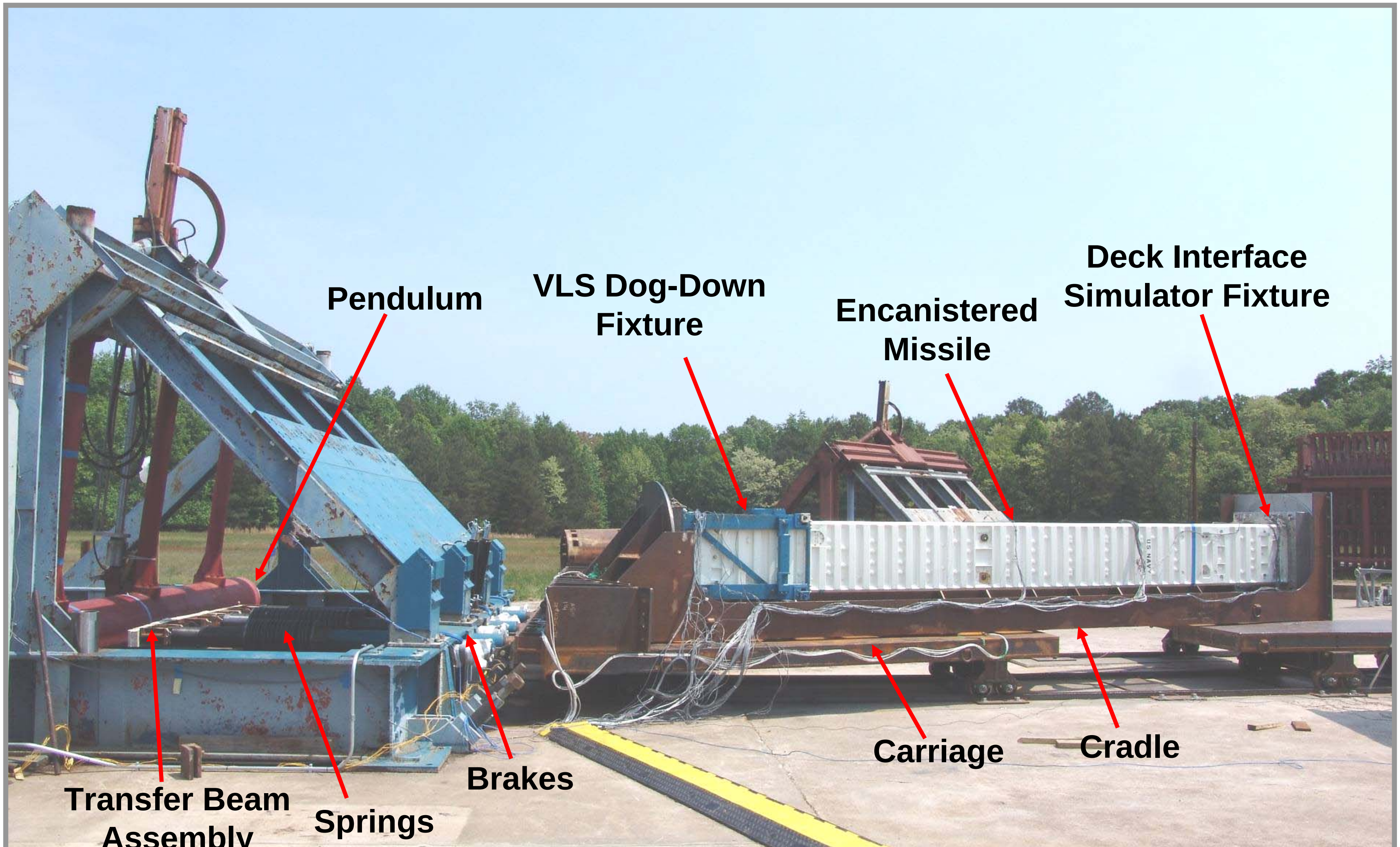
Shipboard Vibration Test Setup (Longitudinal Axis)



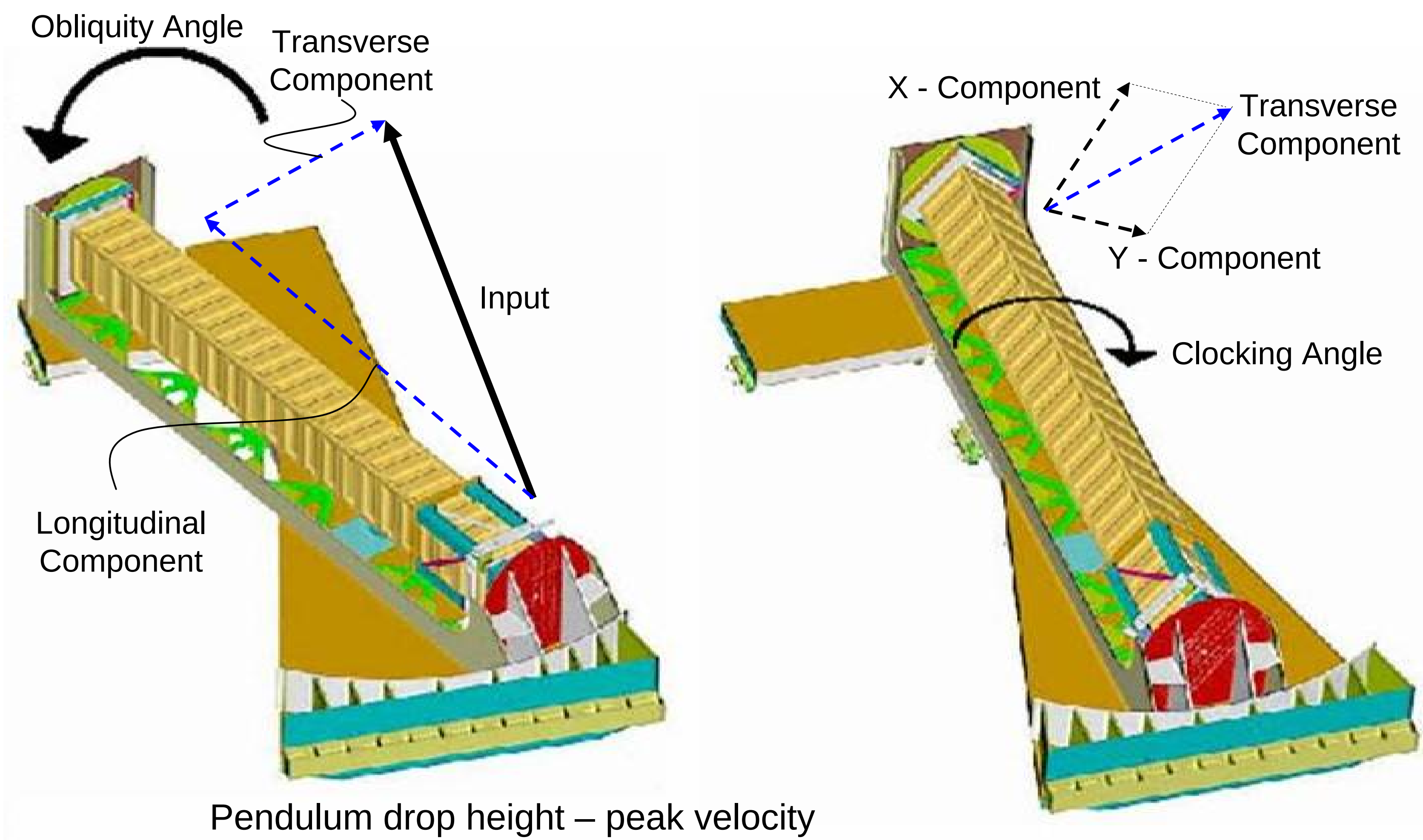
Near Miss Shock Test Method

- Accomplished using DS-3 Shock Machine
  - Large-displacement, pendulum-type impact shock machine
  - Highly-tunable design
    - Continuously adjustable pendulum impact velocity
    - Unique adjustable fixture permits input through 3 principal axes of item
- System-specific tailored test requiring approval from NAVSEA 05P3
  - Alternative to Heavyweight Test (i.e., “Barge Test”) of MIL-S-901
  - Input levels tuned to actual field measurements

Near Miss Shock Test Setup

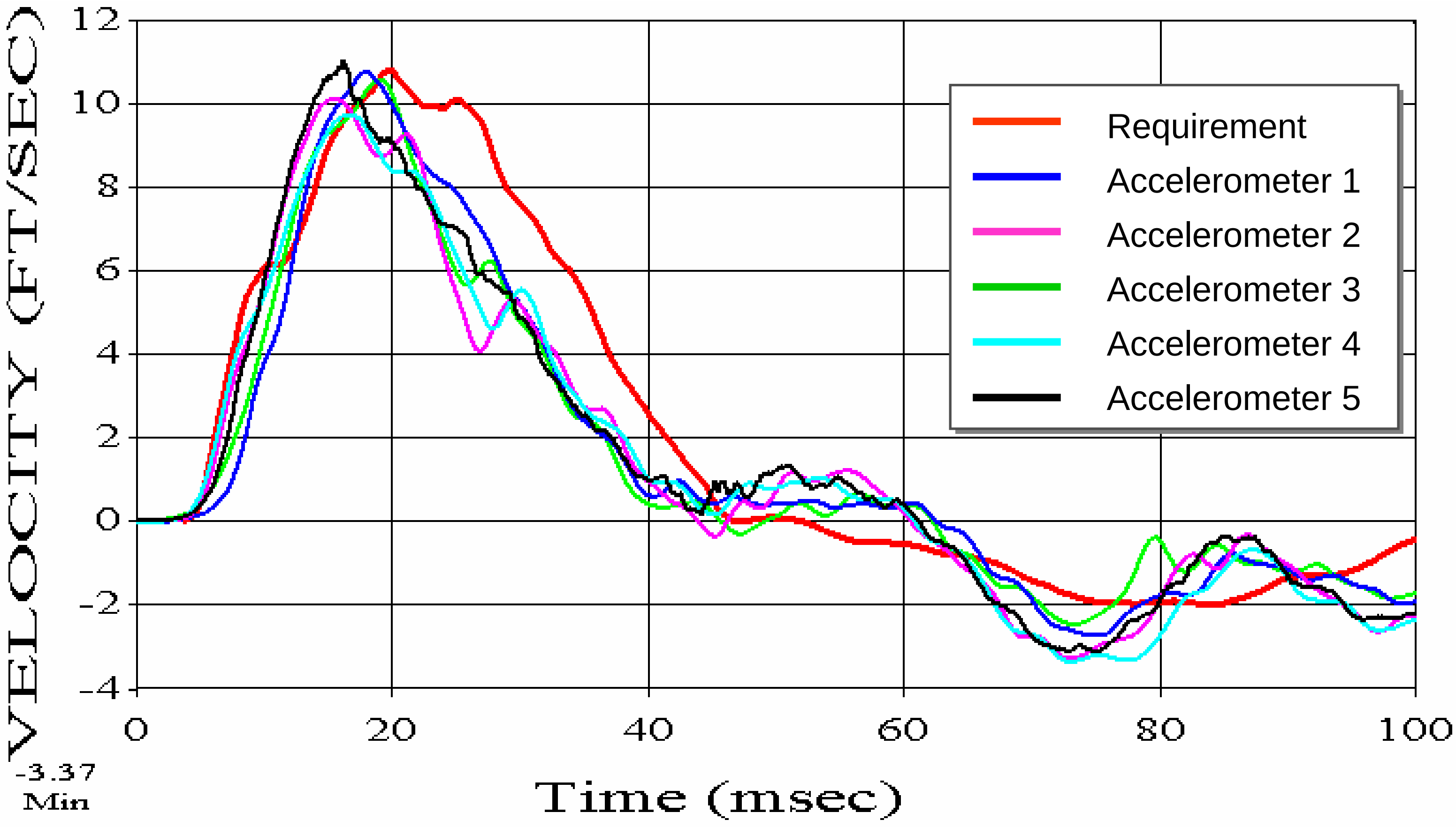


Tuning of Input for Near Miss Shock Test

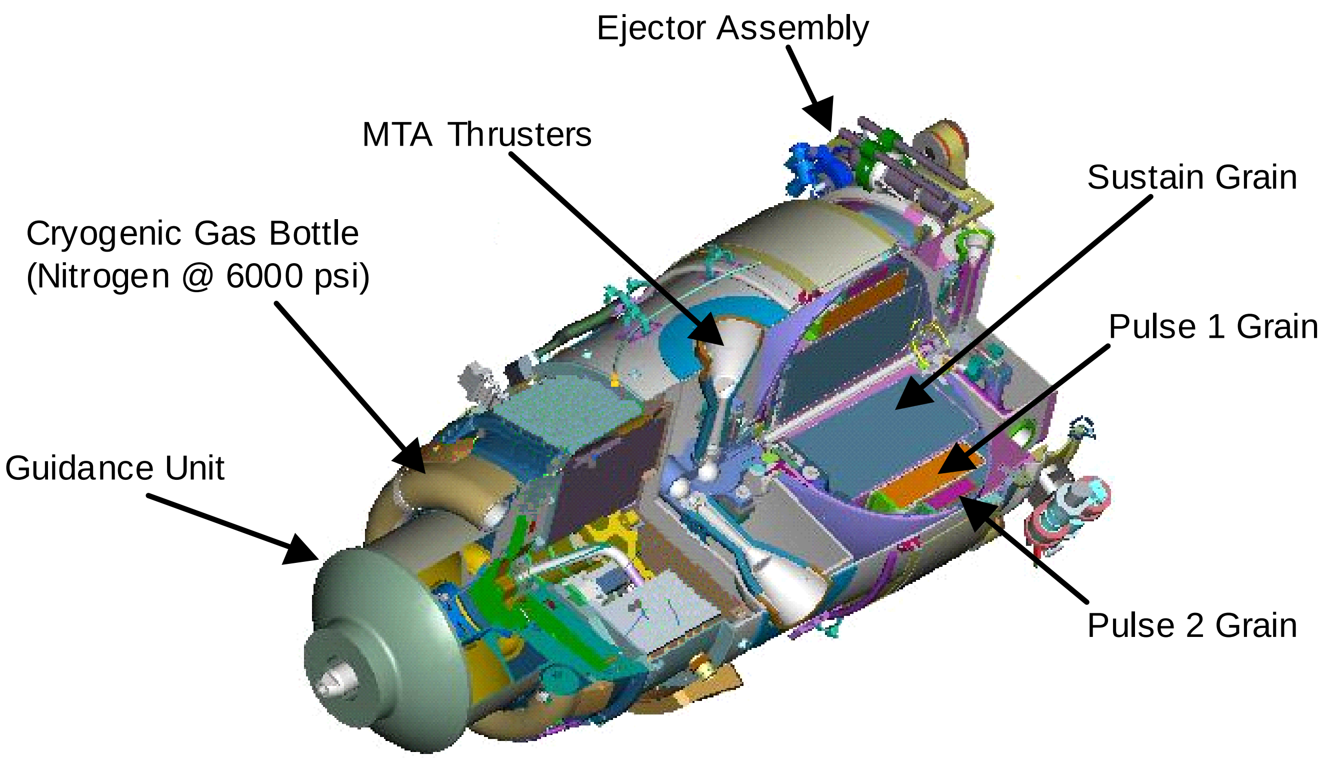


Pendulum drop height – peak velocity
Programmer pad thickness – initial acceleration
Brakes & Springs – initial pulse duration; magnitude of neg. velocity
Obliquity/clocking – Longitudinal and Transverse components

Representative Response Data

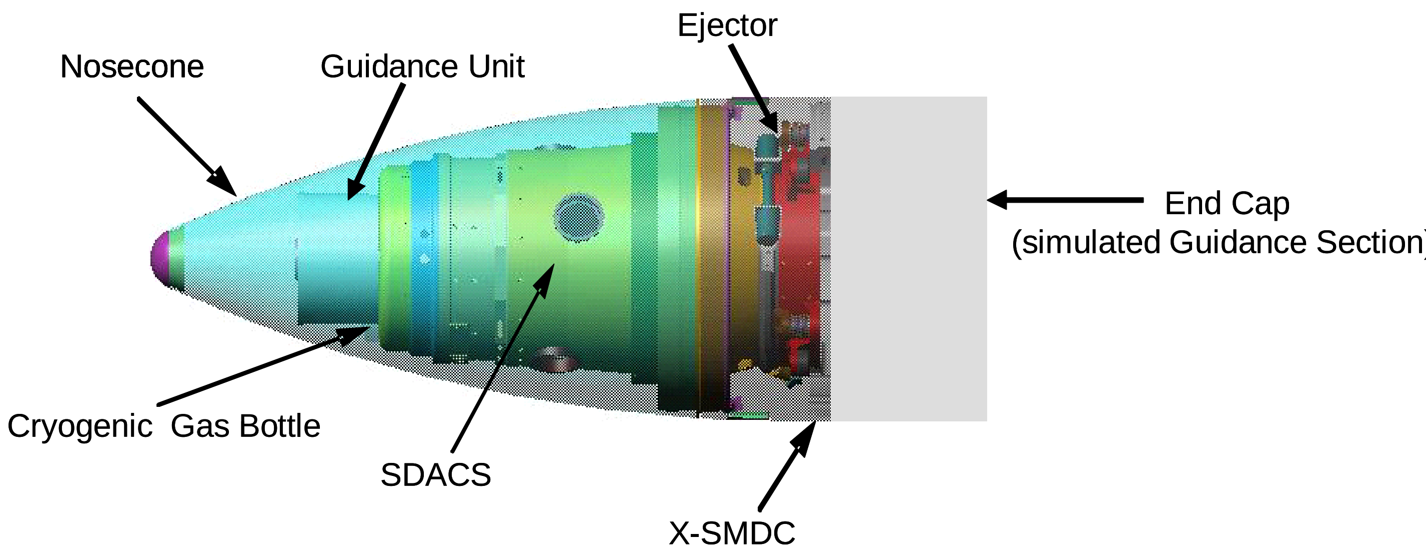


Configuration of Kinetic Warhead



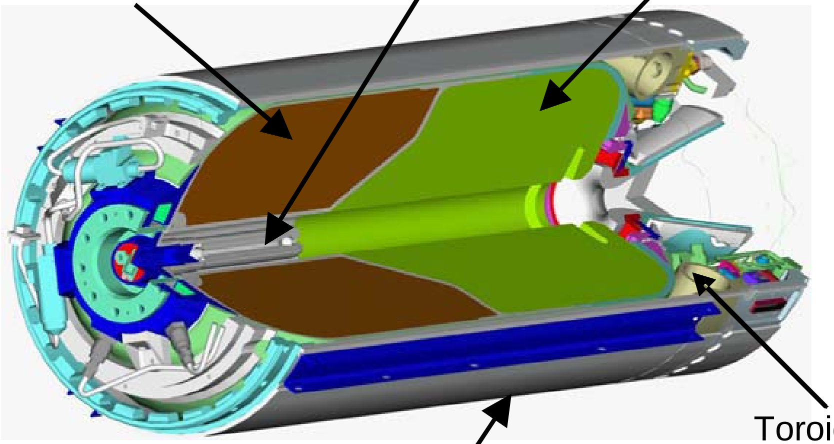
- 3 propellant grains in Solid Divert and Attitude Control System (SDACS)
  - Pulse I grain is TP-H-3510 propellant
  - Pulse 2 grain is TP-H-3511 propellant
  - Sustain grain is TP-H-3512 propellant
- SDACS case is graphite-epoxy composite

Configuration of Kinetic Warhead for Insensitive Munitions Tests



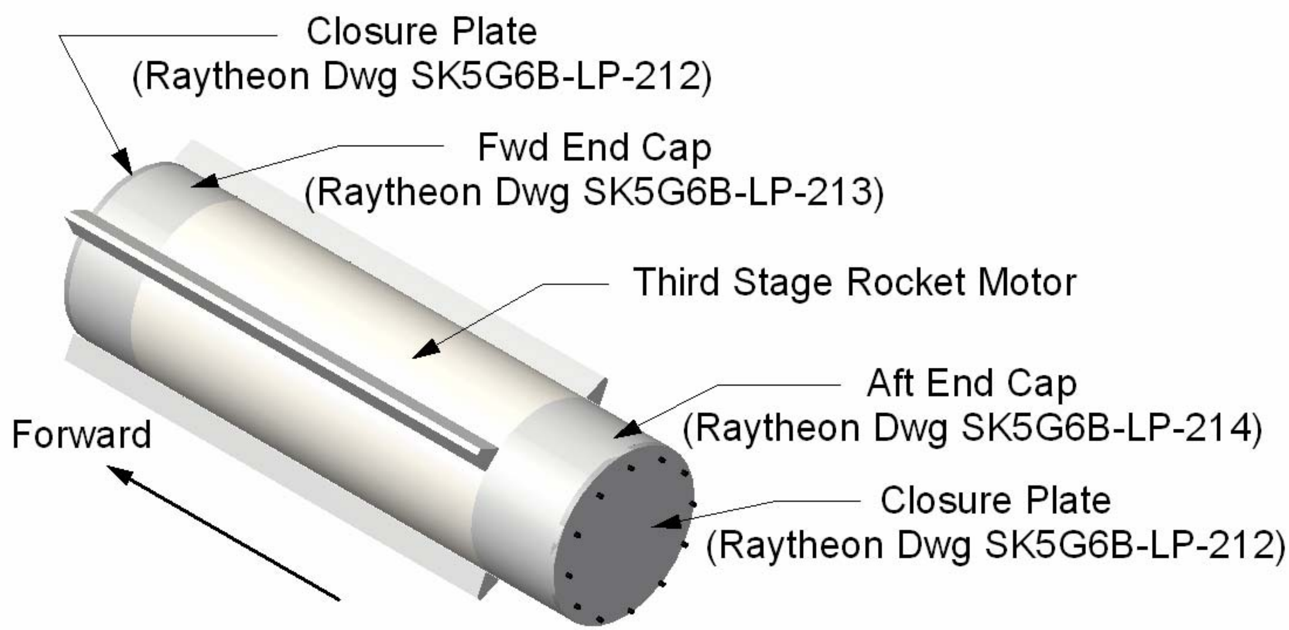
- Kinetic Warhead assembled to simulated Guidance Section shroud
  - 13.625-in OD annular aluminum cylinder with ½-in thick aluminum closure plate
  - Guidance Unit simulated using high-fidelity mass model
  - Cryogenic gas bottle present and fully-charged
- Block IA Nosecone installed over Kinetic Warhead
  - Secured to simulated Guidance Section shroud in same manner as tactical missile
  - All Nosecone explosive components present

General Configuration of Third Stage Rocket Motor



- 2 propellant grains
  - Pulse I grain is TP-H-3518A propellant
  - Pulse 2 grain is TP-H-3518B propellant
- Case sidewall is filament-wound graphite-epoxy composite
- Toroidal cold gas bottle contains pressurized nitrogen

Configuration of Third Stage Rocket Motor for Insensitive Munitions Tests

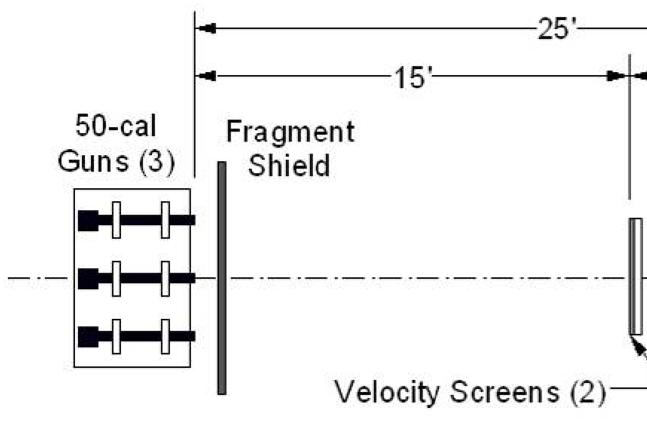


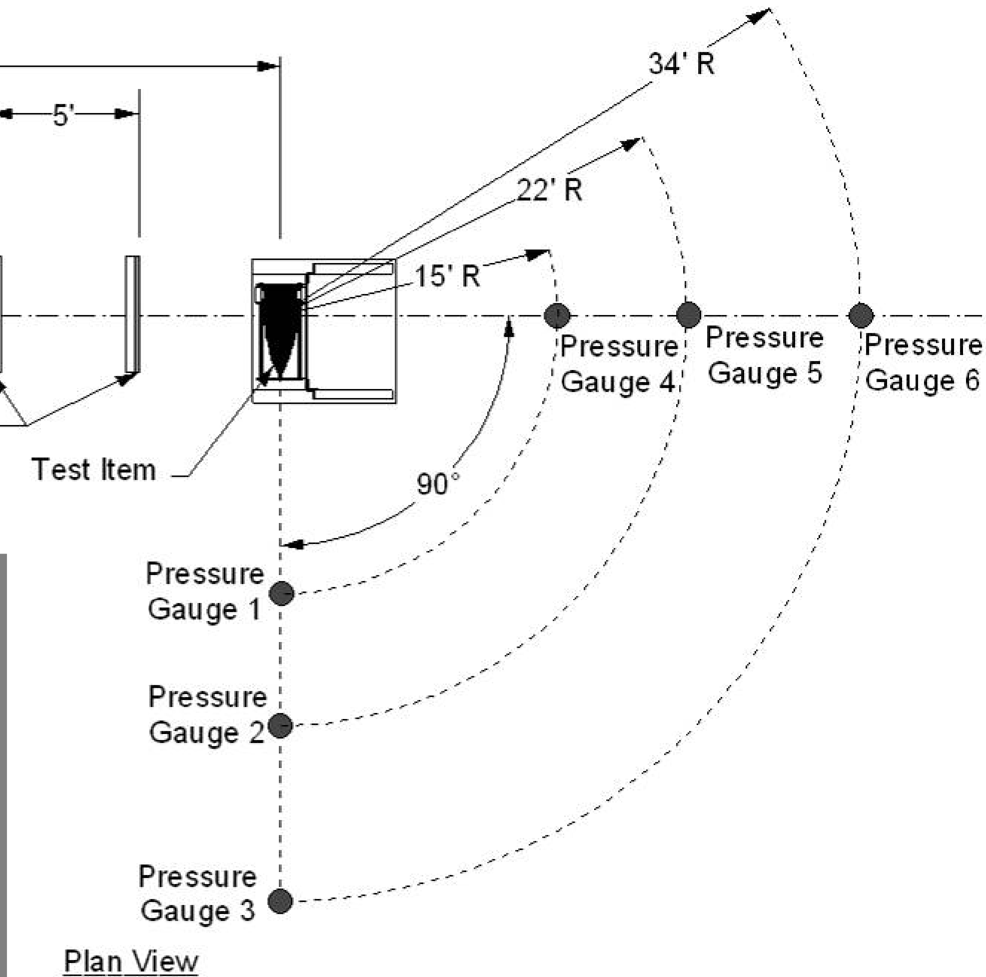
- TSRM assembled with end caps to simulate adjoining missile sections
  - Each end cap is 13.72-in OD annular aluminum cylinder with ½-in thick closure plate
  - Aft end cap secured using 4 explosive bolts
    - Replicate configuration of tactical missile

Bullet Impact Test Method

- Item impacted by three (max) 0.50-cal AP projectiles
  - Velocity of 2800 ± 200 ft/s
  - Bullets fired at 50 ms intervals using three 50-cal Mann barrels
- Trajectory of bullets perpendicular to longitudinal axis of test item
  - Bullets aimed to pass through center of SDACS propellant in KW
  - Bullets aimed to pass through Pulse II grain and ignition tube in TSRM
- Instrumentation and data collection IAW MIL-STD-2105B
  - Gun firing times
  - Bullet velocities
  - Air shock
  - High-speed video record of events
  - Post-test recovery and characterization of remains

Bullet Impact Test Setup

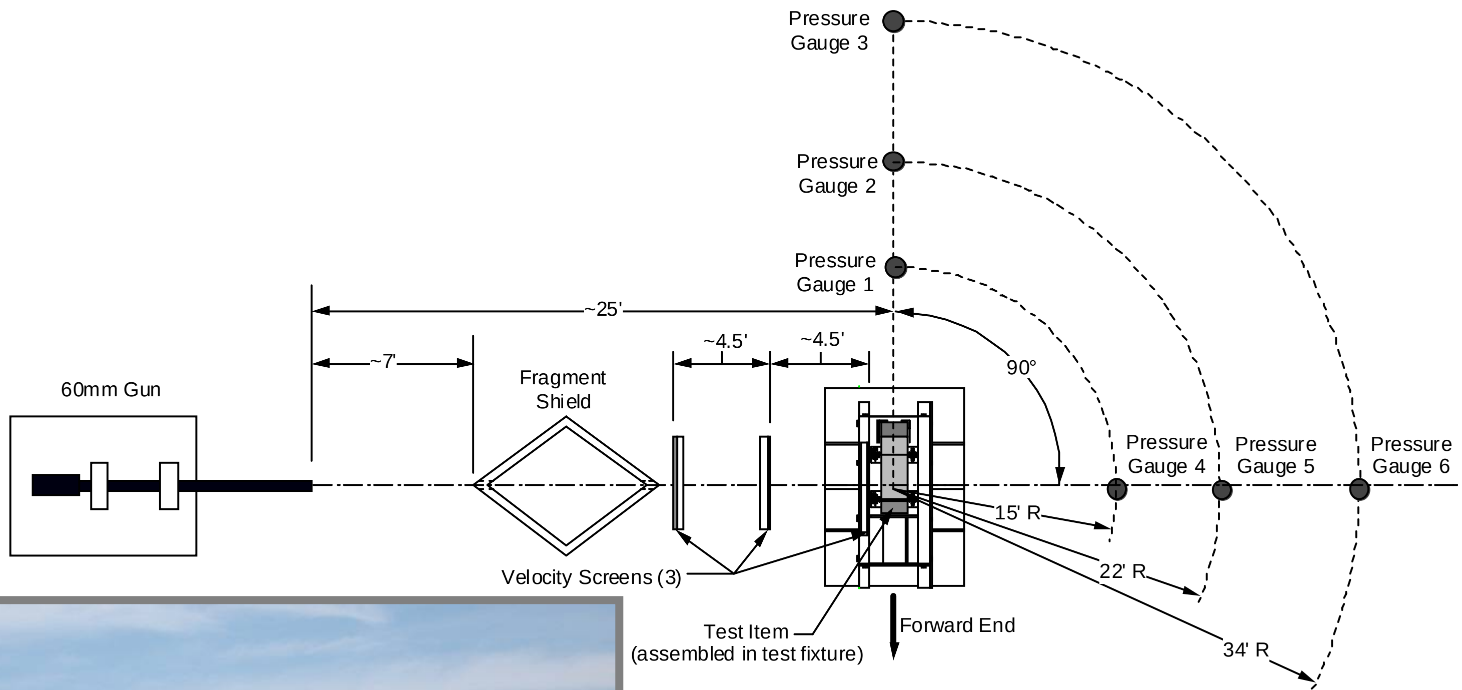




Fragment Impact Test Method

- Item impacted by three ½-in mild-steel cubes
  - Velocity of 6000 ± 200 ft/s
  - Cubes launched using 60mm smoothbore gun and unique FRP sabot
- Trajectory of cubes perpendicular to longitudinal axis of test item
  - Aimed to pass through center of SDACS propellant in KW
  - Aimed to pass through Pulse II grain and ignition tube in TSRM
- Instrumentation and data collection IAW MIL-STD-2105B
  - Cube velocities
  - Air shock
  - High-speed video record of events
  - Post-test recovery and characterization of remains

Fragment Impact Test Setup

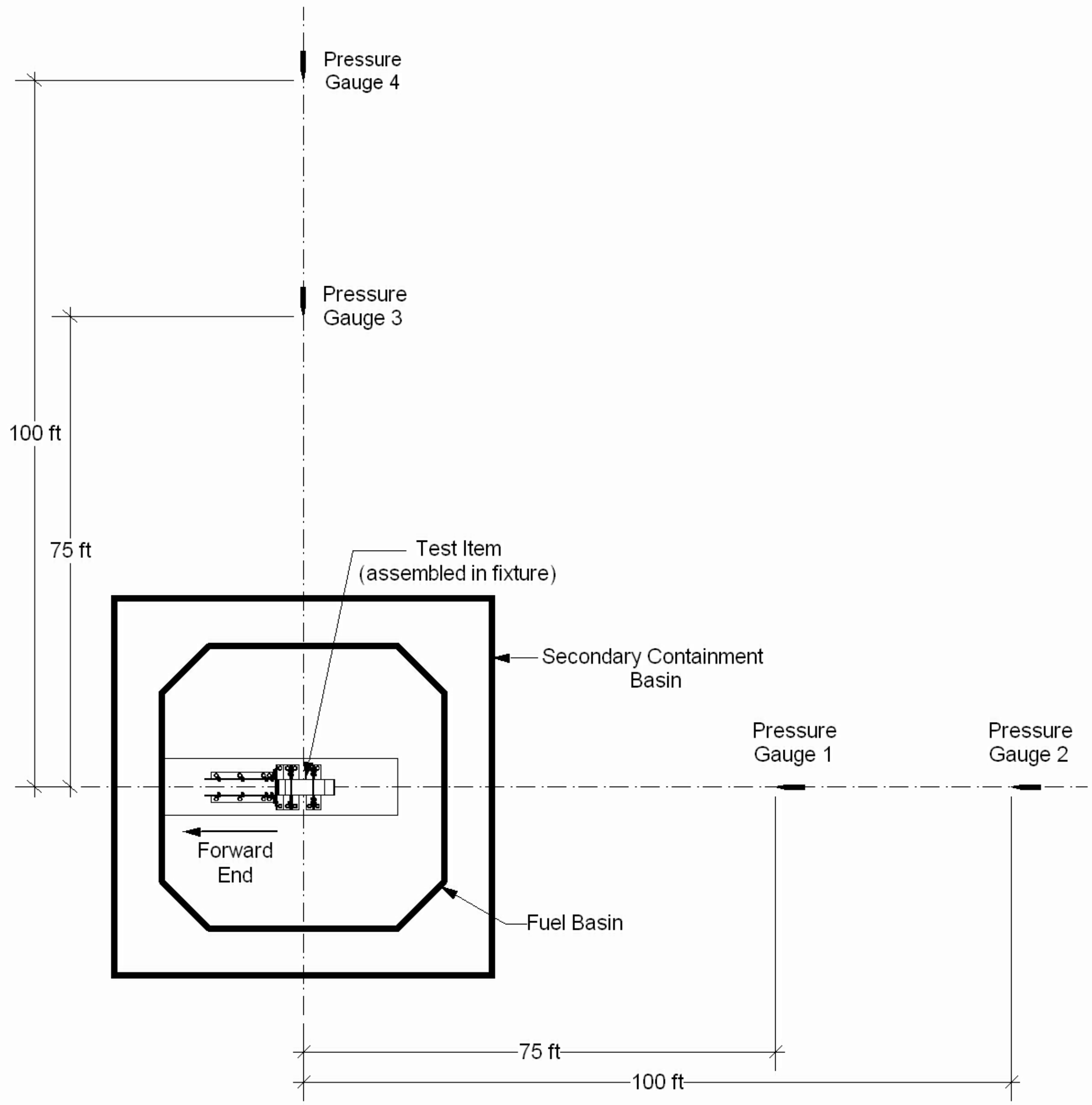


Plan View

Fast Cook-Off Test Method

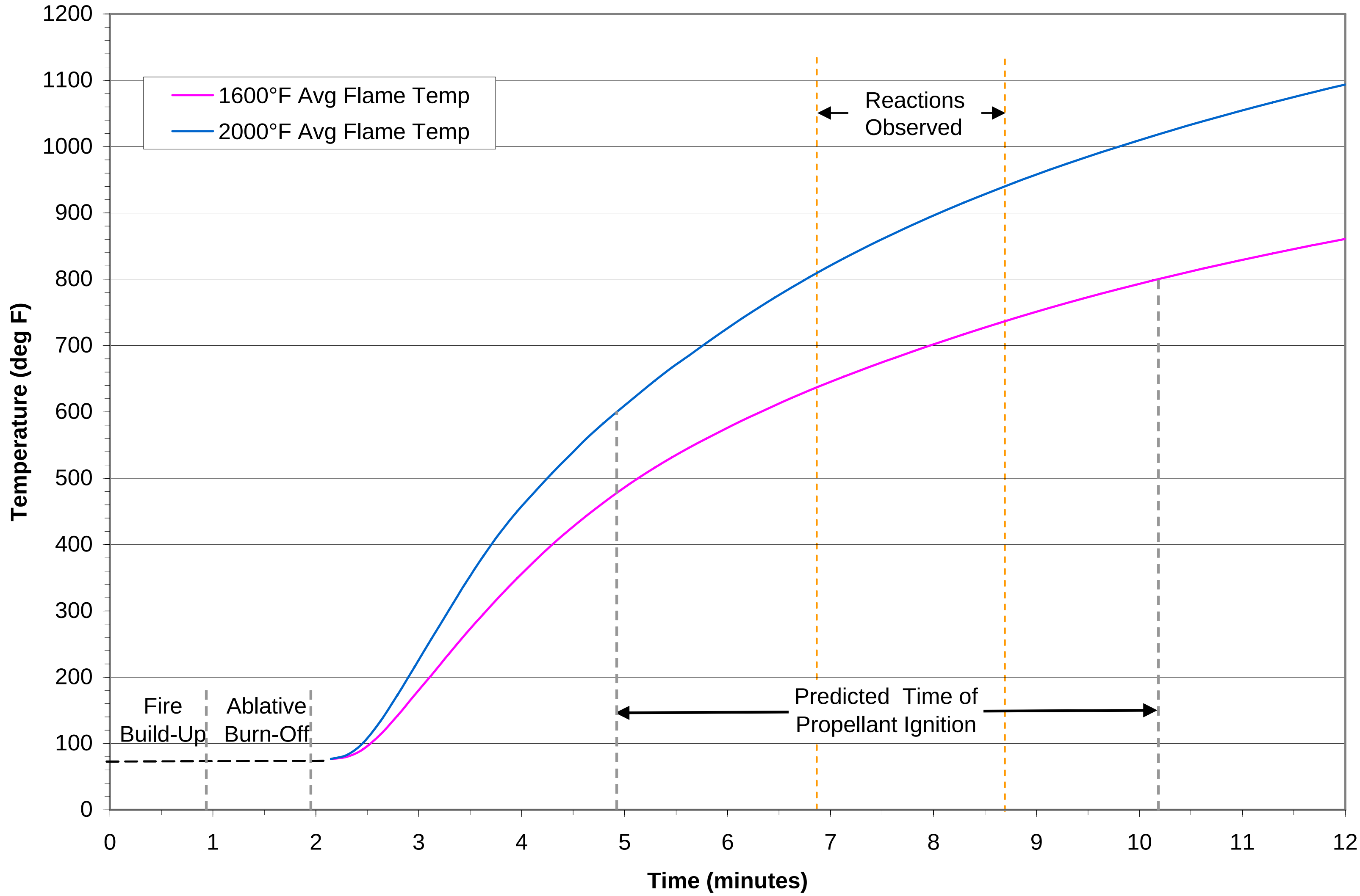
- Item suspended above pool of burning JP-5 aviation fuel
  - Average flame temperature >1600F
  - 30-ft x 30-ft fuel basin used to ensure complete immersion within flame
- Instrumentation and data collection IAW MIL-STD-2105B
  - Flame temperature
  - Air shock
  - Video record of events
  - Post-test recovery and characterization of remains
- Pretest modeling to predict time to reaction
  - 1-D model to examine radial heat transfer through case sidewall
  - Examined two bounding flame temperature conditions
    - 1600°F average flame temperature
    - 2000°F average flame temperature

Fast Cook-Off Test Setup



Fast Cook-Off Test Setup

Predicted Temperature at Liner/Propellant Interface During TSRM Fast Cook-Off



Summary of Test Results

Test	Result
28-Day Temperature & Humidity	No safety-related anomalies
Transportation Vibration	No safety-related anomalies
Shipboard Vibration	No safety-related anomalies
4-Day Temperature & Humidity	No safety-related anomalies
Near Miss Shock	No safety-related anomalies
Bullet Impact	Kinetic Warhead: Type IV reaction (deflagration) Third Stage Rocket Motor: Type III reaction (explosion)
Fragment Impact	Kinetic Warhead: Type IV reaction (deflagration) Third Stage Rocket Motor: Type III reaction (explosion)
Fast Cook-Off	Third Stage Rocket Motor: Type IV reaction (deflagration)

Lessons Learned

- Multi-shaker setup used for Transportation Vibration test introduces additional issues related to phase control
  - Currently not explicitly addressed in MIL-STD-810
  - Accepted / best practices still evolving
- Not possible to achieve same input levels at both ends of canister in Shipboard Vibration test due to fixture dynamics
  - Fact-of-life constraint for single-shaker setup using large, complex fixture
  - Problem most pronounced at higher frequencies
  - New state-of-the-art facility at NSWC/Dahlgren will enable multi-shaker testing in vertical orientation
- Near Miss Shock test demonstrated capability to replicate real-world triaxial shock input to large encanistered missile using pendulum-type shock machine
  - Potential alternative to "Barge Test" for some systems
    - Subject to approval by NAVSEA 05P5 on case-by-case basis
    - May reduce system design risks

More Info

- Test program documented in two NSWCDD technical reports
  - NSWCDD/TR-06/47, Standard Missile - 3 Block IA Hazard Assessment Test Results
    - Draft currently in final review
    - Expect publication and release within a few weeks
  - NSWCDD/TR-06/48, Standard Missile-3 Block IA Near Miss Shock Qualification Test Report

Estimating Durations and Trials to Success in Test Programs

- Click to edit Master text styles

Danny R. Hughes

LMI; University of South Alabama

Jeremy M. Eckhause

LMI

Agenda

- Traditional T&E Schedule Estimation
- Generalized Activity Networks (GAN)
- Example Application: Repeat-until-Pass Test GAN
- Advantages and Disadvantages of GAN Approach
- Extra Topics (Time Permitting)
  - Calibrating GAN Probabilities
  - GANs versus Weibull Distributions

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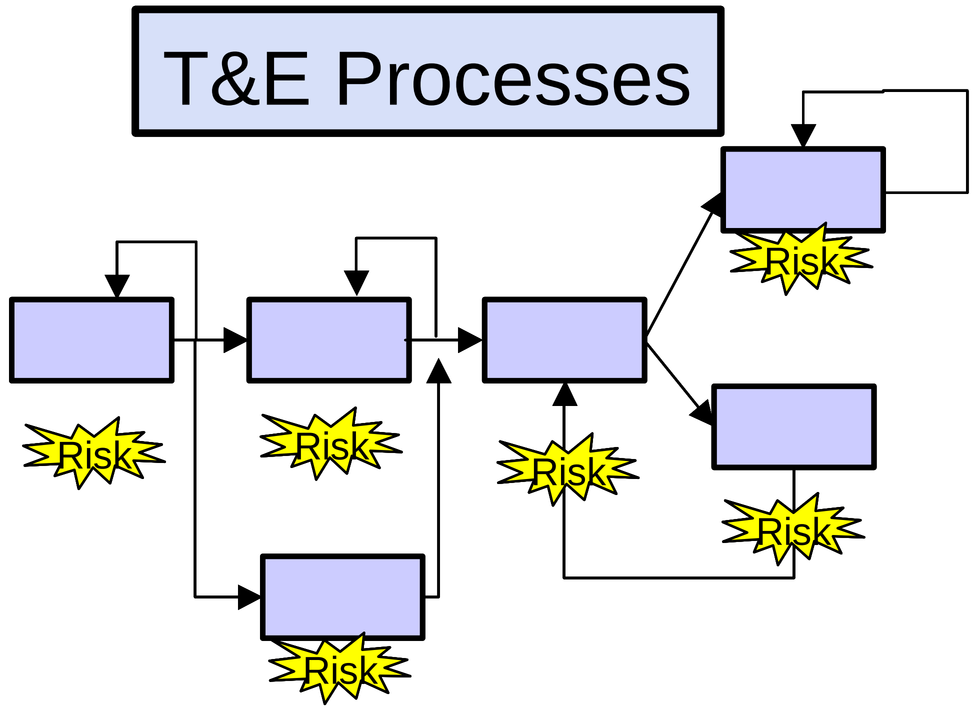
Traditional T&E Schedule Estimation



- T&E programs are inherently risky:
  - Individual WBS elements carry considerable schedule risk
  - There are complex relationships between test objectives, outcomes, and future work
  - Each outcome has complex risks and consequences
  - Not intuitive; difficult to scope

Traditional T&E Schedule Estimation

- T&E schedules are estimated in variety of ways
  - Depends on time, data, precision needed, guidance from program office
- Traditionally, 3 ways to estimate T&E schedules:
  - Factors based upon historical data from analogous systems
  - Parametric Schedule Estimating Relationships (SERs)
    - Linking some characteristic system parameter to historical schedules
  - Detailed bottom-up estimates
- Predominantly driven by projected staffing requirements
- Usually assumes only planned tests

Traditional methods do not account for stochastic events and feedback loops resulting from the recovery from failure

Traditional T&E Schedule Estimation

- Accounting for risk and unknowns is a historical challenge for T&E cost estimation
- Use of historical analogies often fail to adequately account for important distinctions in the new system
- History-based parametric analysis can reasonably estimate the T&E schedules, but provide no information about critical test elements
- Bottom-up estimates provide a wealth of detail on individual test elements
  - Doesn’t account for additional unplanned tests resulting from test failure
  - Schedules are consistently inaccurate and always low
- Generalized Activity Network (GAN) analysis supports the development of more accurate bottom-up SERs

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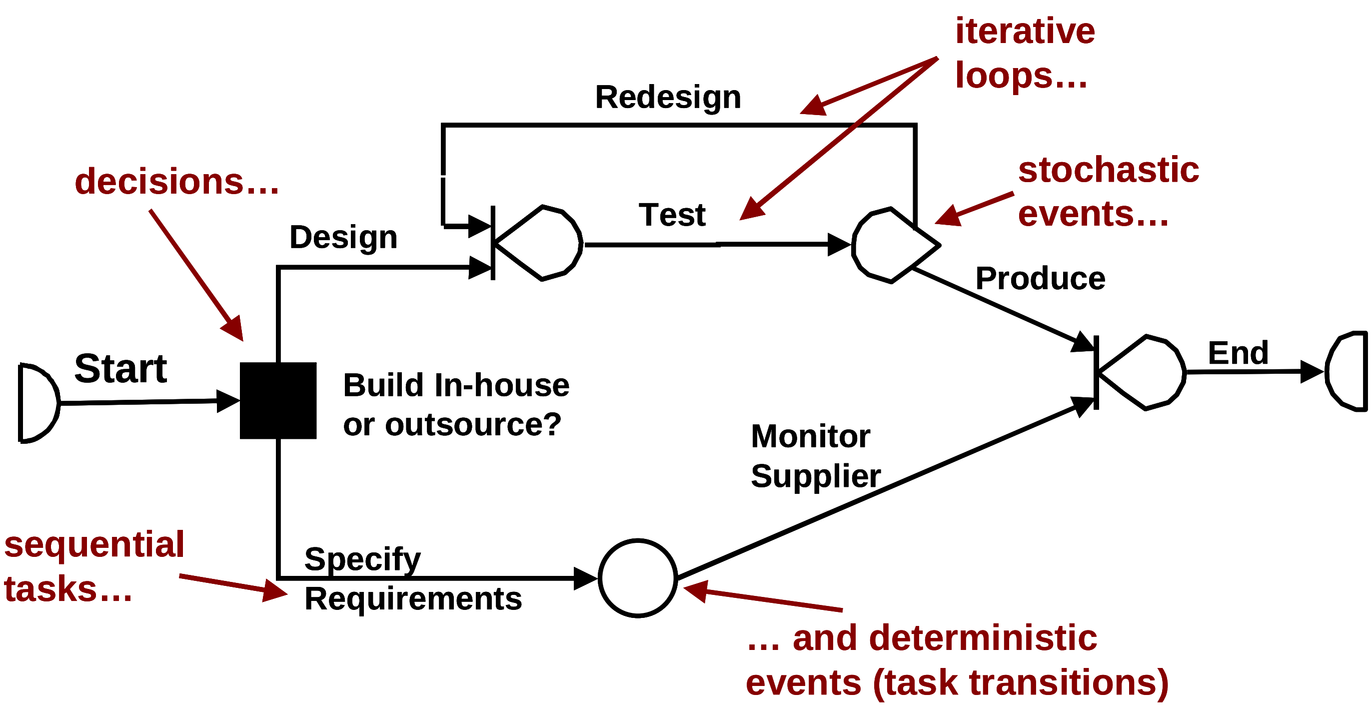
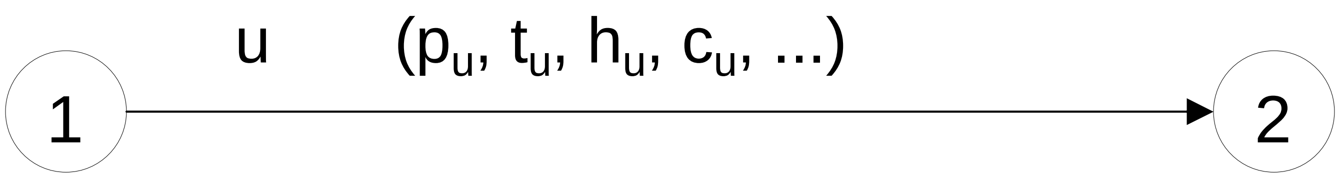
Generalized Activity Networks (GAN)

- A Generalized Activity Network (GAN) is:
  – A cyclical directed process modeling diagram (an extension of PERT)
  – The modeling capabilities of GANs include:



Generalized Activity Networks (GAN)

A GAN has as its basic element an activity (u)



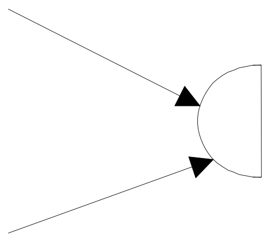
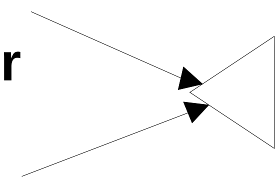
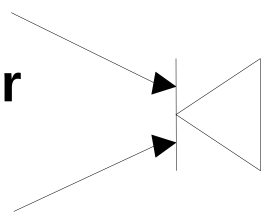
$p_u \equiv$ probability that arc “u” executes

$t_u \equiv$ u’s execution time

$h_u(t_u) \equiv$ probability density function for t

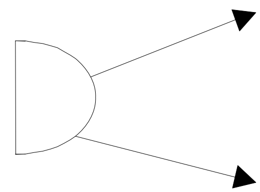
$c_u \equiv$ u’s cost: may depend upon t

GAN Junctions

GAN Receivers		
And (AND)		All arcs must execute to continue
Inclusive Or (OR)		Continue after any arc completes
Exclusive Or (XOR)		Must complete exactly one arc to continue

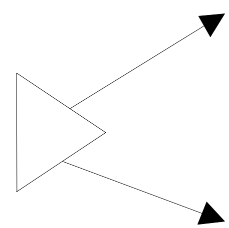
GAN Transmitters

Must follow



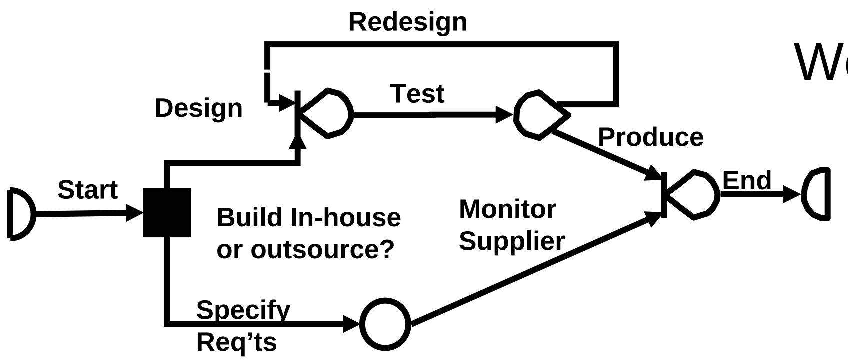
All arcs execute

May follow



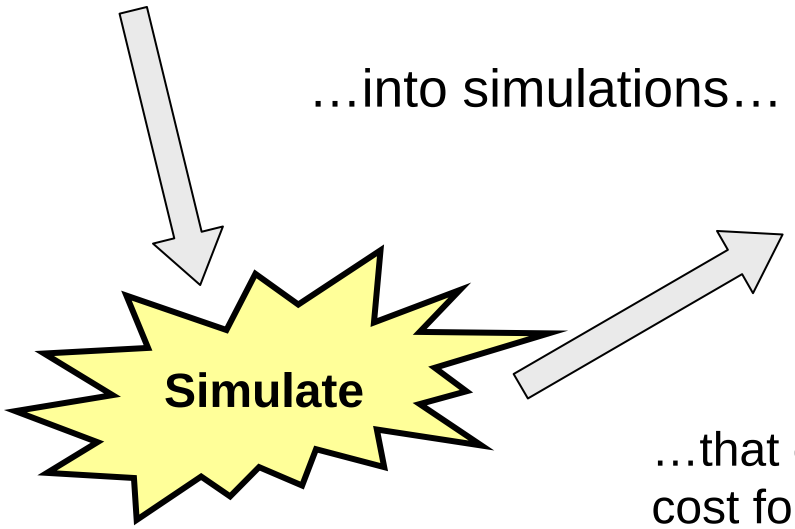
Arcs execute with assigned probabilities

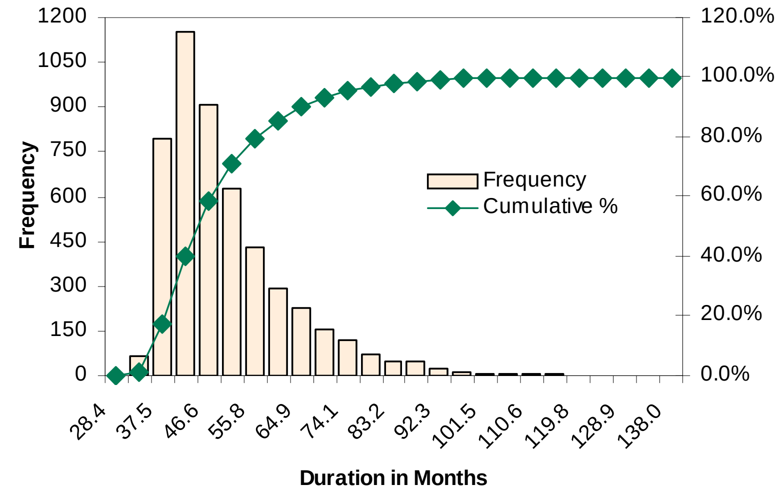
GAN Simulations



We convert GANs…

…into simulations…





…that can compute completion time and cost for complex spending programs.

Our research shows that these simulations provide a surprising amount of insight, even with few inputs

How GANs are Built and Calibrated

- Modeling process:
  - Build a network diagram (GAN) to describe possible program execution paths
  - Estimate parameters: establish random distribution(s)
  - Require probabilities for feedback loops or other event outcomes
  - Create a discrete-event simulation for that network
- Parameter estimation:
  - Task durations, cost, and risk levels can be based on:
    - Build-up estimates, calibration with historical data, subject matter expertise
    - Often apply a Weibull distribution (Gladstone-Miller 2002 DODCAS) to deterministic estimate
  - Feedback probabilities can be calibrated with historical data from similar programs or subject matter experts

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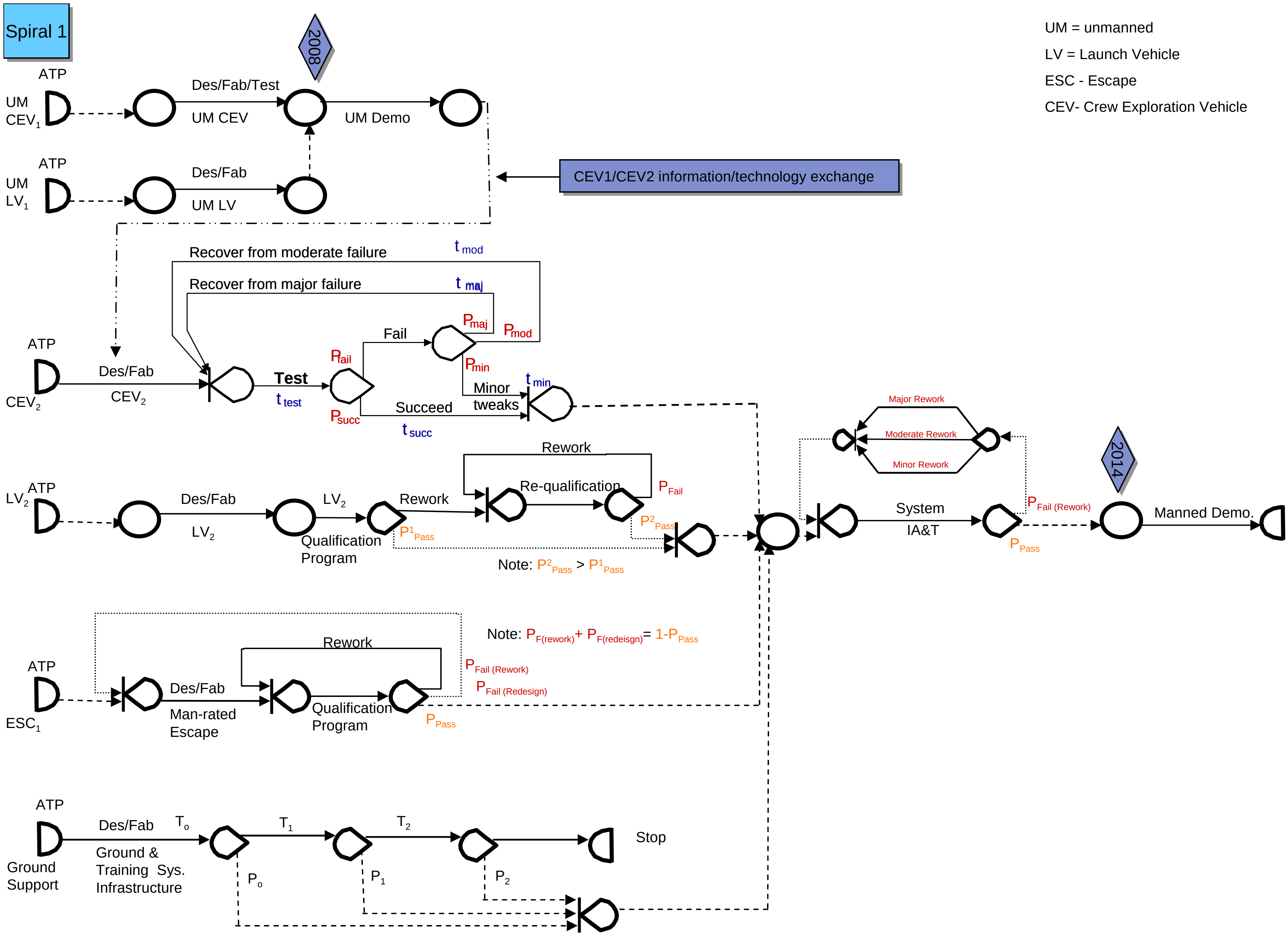
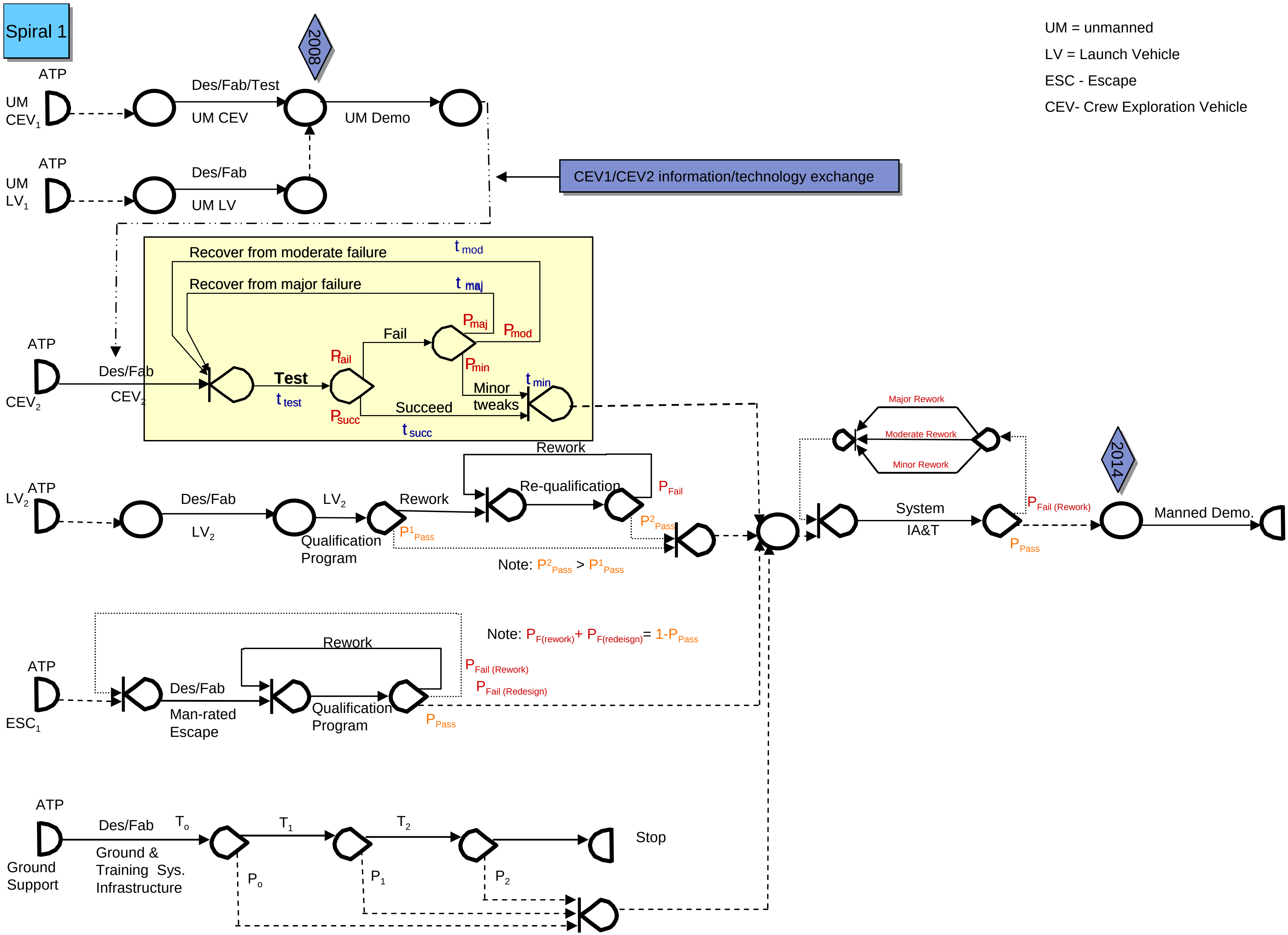


Spiral 1
2008
ATP
UM CEV1
Des/Fab/Test
UM CEV
UM Demo
ATP
UM LV1
Des/Fab
UM LV
CEV1/CEV2 information/technology exchange
UM = unmanned
LV = Launch Vehicle
ESC - Escape
CEV- Crew Exploration Vehicle
Recover from moderate failure
t mod
Recover from major failure
t maj
ATP
CEV2
Des/Fab
CEV2
Test
t test
Pfail
Fail
Pmaj
Pmod
Pmin
Minor tweaks
t min
Psucc
Succeed
t succ
ATP
LV2
Des/Fab
LV2
LV2
Qualification Program
Rework
Rework
Re-qualification
PFail
P1Pass
P2Pass
Note: P2Pass > P1Pass
Major Rework
Moderate Rework
Minor Rework
2014
System IA&T
PFail (Rework)
PPass
Manned Demo.
ATP
ESC1
Des/Fab
Man-rated Escape
Rework
Qualification Program
Note: PF(rework)+ PF(redeisgn)= 1-PPass
PFail (Rework)
PFail (Redesign)
PPass
ATP
Ground Support
Des/Fab
Ground & Training Sys. Infrastructure
To
T1
T2
Po
P1
P2
Stop


Spiral 1
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CEV1/CEV2 information/technology exchange
Recover from moderate failure
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CEV2
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CEV2
Test
t test
Psucc
Minor tweaks
t min
Succeed
t succ
Major Rework
Moderate Rework
Minor Rework
2014
Rework
ATP
LV2
Des/Fab
LV2
LV2
Rework
Re-qualification
PFail
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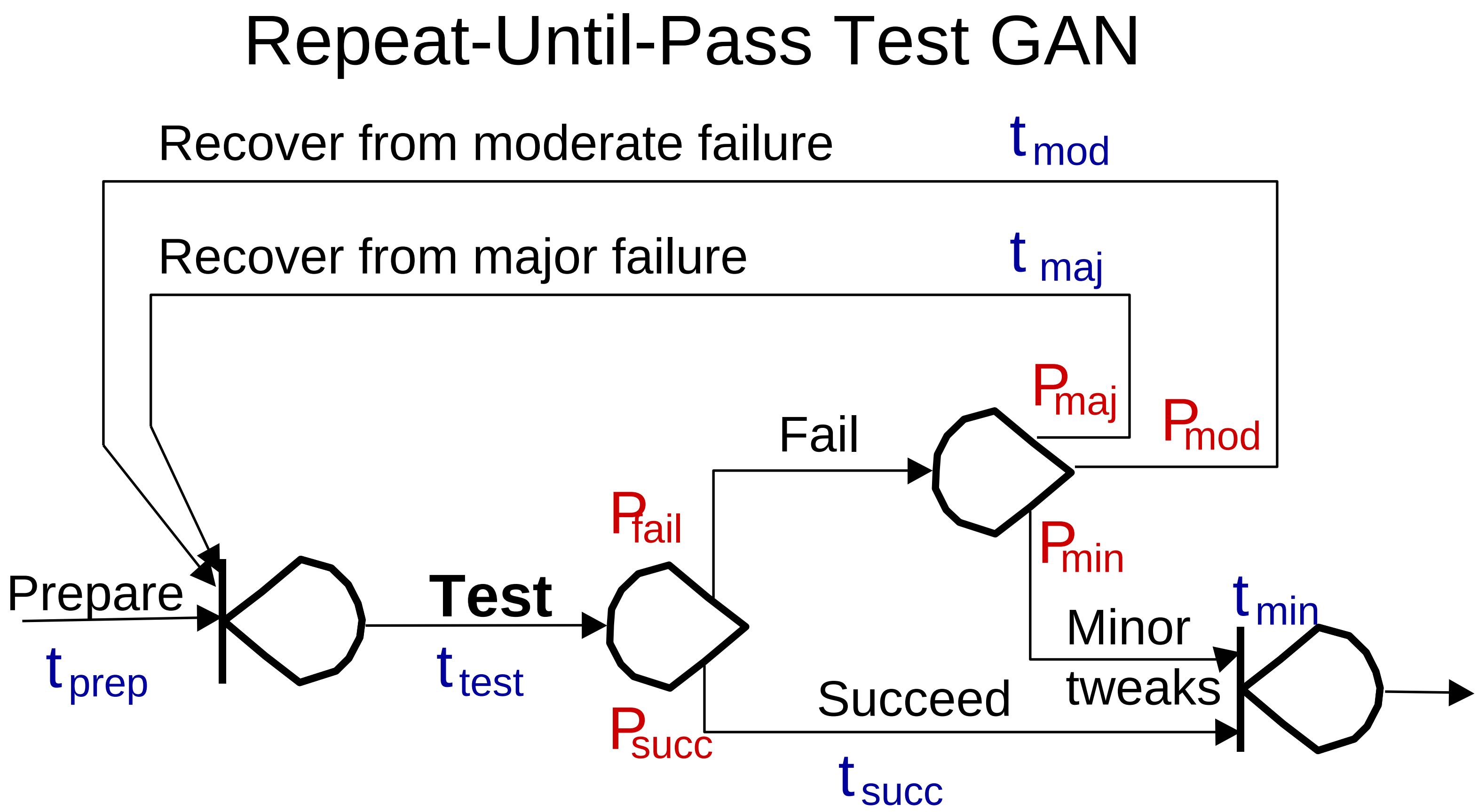
PFail (Redesign)
PPass
ATP
Ground Support
Des/Fab
Ground & Training Sys. Infrastructure
To
T1
T2
Stop
Po
P1
P2

Example: Repeat-Until-Pass Test GAN



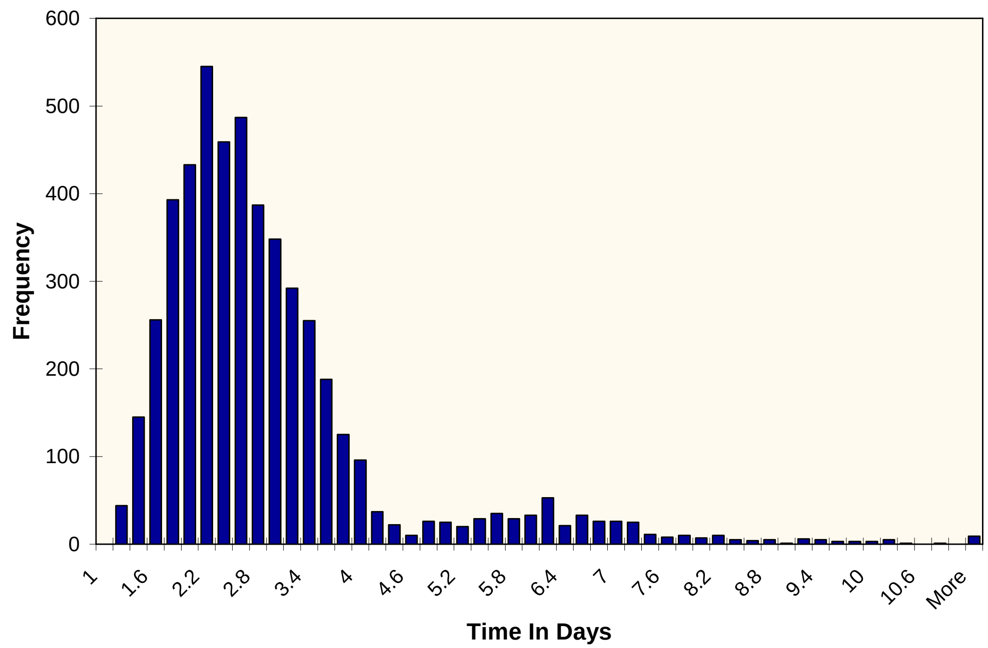
Most likely task durations in blue

Event outcome probabilities in red

Example: Repeat-Until-Pass Test GAN

- Durations for Preparation and Testing:
  - Uniform Random Variables
  - Expectation 1 day & Range 1 day: U(0.5,1.5)
- Durations for Recovery from Test Failure:
  - Minor Failure: U(0.5,1.5) Exp. Value: 1 day
  - Moderate Failure: U(1.25,2.75) Exp. Value: 2 days
  - Major Failure: U(2.0, 4.0) Exp. Value: 3 days
  - Note: Dispersion also increases with failure severity
- Duration for activities following success is 0
- $P_{success} = P_{failure} = .5$
- $P_{min} = .8$; $P_{mod} = P_{maj} = .1$
  - 10% of all failures are moderate, and 10% of all failures are major

Example: Repeat-Until-Pass Test GAN



- Performed Monte Carlo Simulation
- Expected Duration for Test Success: 2.8 days
- Large right-tail dispersion due to geometric distribution from inclusion of a probability of test failure

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GAN Advantages

- Hierarchical: can describe and analyze system at any level of detail
- Flexible: supports evaluation and decision-making at all levels
- Model iterative processes
- Can provide more information than simple time/cost estimates
  - Complete distribution; eliminates need for separate risk analysis
  - Identify potential problem activities for risk mitigation
- Often provide useful insight during both design (diagramming) and analysis (simulation, analytic equations) phases
- Provides a single integrated approach for understanding task interdependencies; identifying high-risk activities; and incorporating funding constraints

GAN Disadvantages

- "Uniqueness" problem
  - Data cannot be used for calibration if too program-specific
  - Breadth of data as important as depth of data
- May suffer from subjectivity of expert opinion data
  - Problem of all bottom-up estimates
- Requires detailed program data
  - Data necessary for calibration
  - Calibration necessary for meaningful schedule estimates
- "Familiarity" problem: Although growing, GANs currently not widely used for cost analysis

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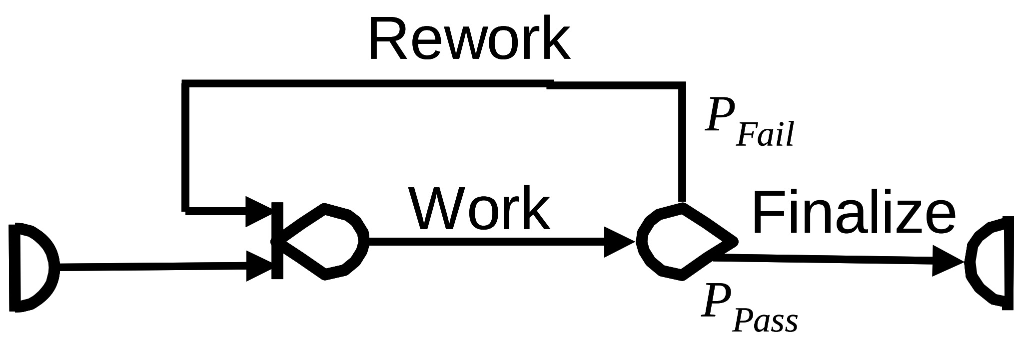
Calibrating GAN Probabilities

- We consider two common GAN feedback processes
  - The One "P" Case
    - Single feedback loop with a constant probability of success
    - Preliminary results included in MORS presentation
  - The Two "P" Case
    - Successive attempts after the first failure possess a constant, but higher, probability of success that the first test trial
    - Presumes that most of the major problems are at least identified after recovery from initial failure implying a higher probability of success for subsequent trials

GAN Probabilities: One "P" Case



- Typically, probabilities of success or failure driven by expert opinion
- Probabilities *can* be appropriately calibrated by historical data
- Assumptions
  - Well defined, common test event for commodity/system
  - Access to historical data from similar systems

GAN Probabilities: One "P" Case

- Considering simple test-block GAN:
  - Trials occur until a success is achieved (with probability P for each trial)
  - Let X be the number of trials until the first success
  - X is a geometric random variable with parameter P
  - Specifically,

$$E[X] = \frac{1}{p}$$

- Assuming historical data (of sample size n) on number of trials from similar systems can solve for single p^* that minimizes the sum of squared errors between the expected number of trials predicted by the GAN, $E[X]$,and the historical data

GAN Probabilities: One "P" Case

- Thus, if $x = \frac{1}{p^*}$ and $\{b_1, b_2, b_3, \ldots, b_n\}$

  are the set of outcomes representing the number of trials for independent outcomes of the same GAN, we wish to:

$$\min \sum_{i=1}^{n} (x - b_i)^2$$

$$subject\ \ to : x \geq 1$$

- Conveniently, the global minimum is simply the mean of the historical data, yielding:

$$p^* = \left(\frac{\sum_{i=1}^{n} b_i}{n} \right)^{-1}$$

One "P" Case: Proof

- Since our problem is only over one dimension, we can simply consider looking at the derivative of the function with respect to $\boldsymbol{x}$

$$\sum_{i=1}^{n}(x-b_i)^2 \quad = \quad \sum_{i=1}^{n}(x^2-2b_ix+b_i{}^2) \quad = \quad nx^2-2x\sum_{i=1}^{n}b_i+\sum_{i=1}^{n}b_i^2$$

- Taking the derivative of this expression and setting it to zero, we get that:

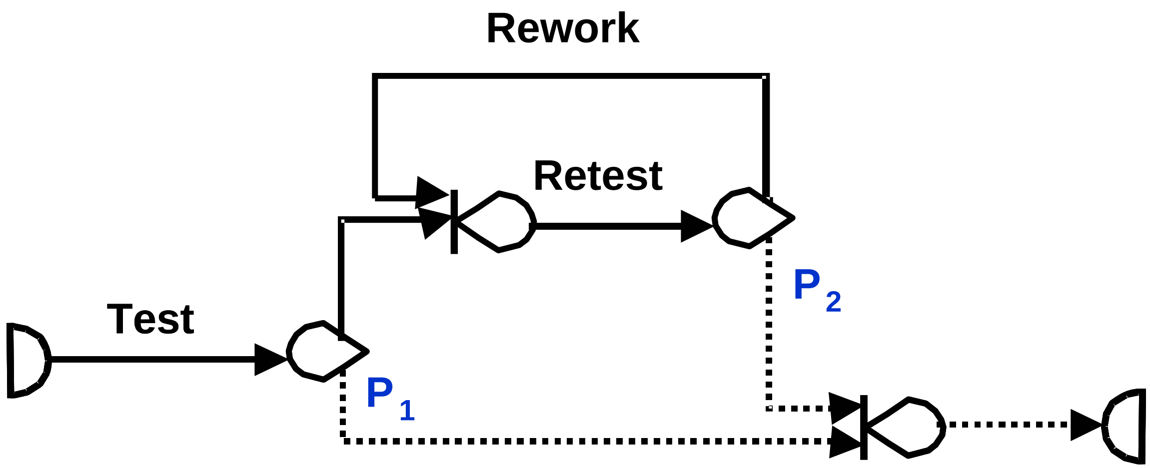
$$2nx-2\sum_{i=1}^{n}b_i=0 \qquad \Rightarrow \qquad x=\frac{\sum_{i=1}^{n}b_i}{n}$$

- Thus, we can estimate $\boldsymbol{p^*}$ by simply by taking the inverse of the average of the outcomes of the trials

GAN Probabilities: One “P” Case

- This simple, straightforward result is powerful because analysts can easily ***objectively*** calibrate GAN probabilities
- Further, in absence of historical data, analysts should seek
  - Unbiased expert opinion on “average” number of tests until success
  - Should produce better estimates of realistic probability of success than directly asking for them

GAN Probabilities: Two “P” Case



- Probability of success on first test: P_1
- Probability of success on every other test, *conditional* on first test failing: P_2
  - Might expect $P_2 > P_1$ due to knowledge of what failed, additional effort spent on that item, etc.

GAN Probabilities: Two "P" Case

- Consider a test event with the following historical data:

Historical Program	# Trials until Success	1st Trial Success? (Yes=1, No=0)	2nd Trial? (Did the 1st trial fail?)	# of "P2" Trials
1	6	0	1	5
2	7	0	1	6
3	4	0	1	3
4	1	1	0	0
5	8	0	1	7
6	1	1	0	0
7	2	0	1	1
8	1	1	0	0
9	12	0	1	11
10	4	0	1	3

- We could calculate a single probability, *p*, using the previous technique
  - Method of calibrating P_1 and P_2 should reduce to One "P" case if probabilities are constant

GAN Probabilities: Two “P” Case

- Let x_1 and x_2 be decision variables and $\{b_1, b_2, b_3, \ldots, b_n\}$ historical data.
- Let $b_1^i = 0$ if the first trial failed and $b_1^i = 1$ if it succeeded and assume that there are J successes.
- Let b_2^j represent the number of subsequent trials with a probability, p_2 ,of success
- As before, we wish to minimize the sum of squared errors between the expected number of trials predicted by the GAN and the historical data for each decision node:

$$\sum_i (x_1 - b_1^i)^2 + \sum_j (x_2 - b_2^j)^2$$

GAN Probabilities: Two "P" Case

- We can minimize each sum separately, yielding $\boldsymbol{x_1}$ and $\boldsymbol{x_2}$, and thus our $\boldsymbol{P_1}$ and $\boldsymbol{P_2}$
- Using the data from our example we produce the probabilities:

$$P_1 = x_1 = 0.3$$

$$P_2 = \frac{1}{x_2} = \frac{1}{36/7} = 0.1944$$

- Monte Carlo testing demonstrates method to provide robust estimation of data generating process even when $\boldsymbol{P_1} = \boldsymbol{P_2}$

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Weibull Enveloping Distributions

- Evaluate feasibility of estimating hyper-geometric processes through an enveloping Weibull distribution
- Why?
  - Hyper-geometric processes and Weibull distributions are similarly right tailed
  - Weibull distributions are well understood throughout cost community and, thus, better accepted than GAN feedback simulations
- Study Objective: See if its possible to fit a Weibull to a feedback process under ideal conditions, ie. when we actually possess full knowledge of the process and relevant statistics

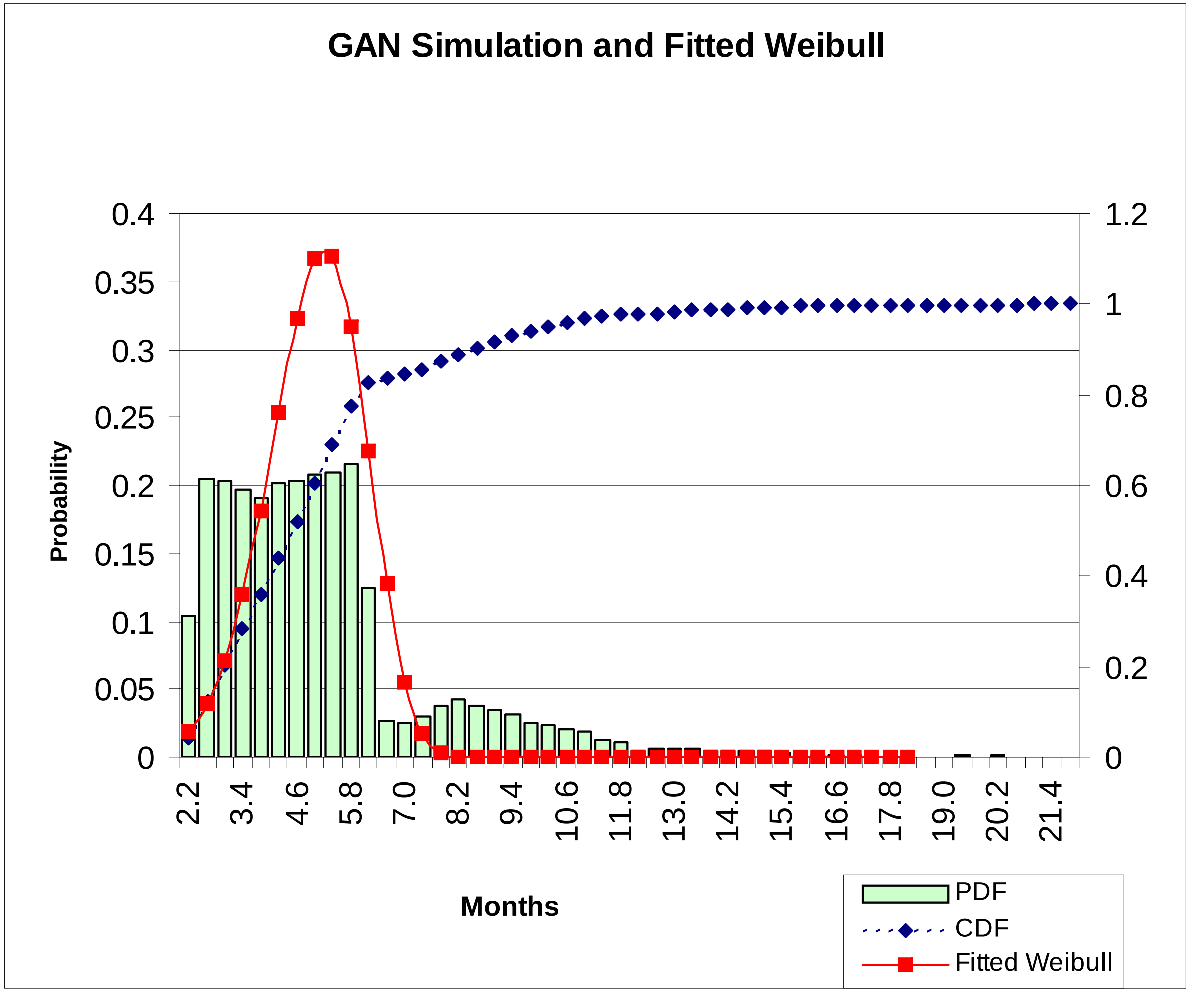
Weibull Enveloping Distributions

- Method for matching GAN simulation results through Weibull distributions:
  - Create GAN simulation to generate hyper-geometric data
    - Can be calibrated with different underlying probabilities and duration distributions
    - Produce test data from 10,000 trials to ensure robust characterization of data generating process (can employ asymptotic theory)
  - Optimize Weibull parameters to fit the distribution to generated data
    - Identify appropriate metrics to define “goodness of fit”
    - Perform optimization upon selected objective function
  - Evaluate “best-fitting” Weibull predictions to simulated results

Weibull Enveloping Distributions

- Population Data: Data Generating Process
  - Relatively straightforward parameters to maximize probability of successful fit
  - Trial Durations ~ Uniform (2,6)
  - Feedback Probabilities: 50/50, 80/80, 30/30, 50/80, etc.
- Goodness of fit
  - Cost and Schedule Estimates typically reported at the mean [expected value], 50% CDF, and 80% CDF
  - If we know two of the three, we can optimize the selection of Weibull parameters (α,β) to minimize the error between the prediction for the third metric and simulated data
  - If we assume we only know the expected value of the data, we can optimize parameters such that we minimize the joint error between the 50% and 80% CDF

Characteristic Result



Weibull Enveloping Distributions

- Our analysis on a variety of simple GAN simulations indicates that it is not feasible to adequately envelope a GAN feedback loop with a single Weibull distribution
- Enveloping Weibull performs worse under more complex, realistic assumptions such as Normal or Weibull distributed durations in the population data generating process
- For a few specific cases we were able to fit a Weibull with a relatively small mean squared error, e.g. a prediction error of less than 20%
  - However, calibration was made with our complete knowledge of the underlying data generating process, which we would not have with real data.

Weibull Enveloping Distributions

- Successful fit only indicates that it is feasible for a Weibull to approximate a specific feedback process *not that it can actually be implemented with statistical confidence*
  - Wouldn't actually possess information on the expected value, 50%, or 80% CDF with real data from which to optimize Weibull
  - Weibull parameters would be calibrated, as always, from outside of the estimated process
  - Fitting arbitrary points of a CDF does not necessarily indicate a minimization of the error between the Weibull and simulated data mass functions
- We recommend the continued use of GAN feedback loops to simulate feedback processes, such as testing.

A Continuum of Testing

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DOT&E

Pharmaceutical Testing

- Laboratory Testing
- Animal Testing: Effectiveness & Safety
- FDA review: Decision to allow clinical trials
- Clinical trials: Effectiveness & Safety
- Very costly consequences of unexpected serious side effects after distribution, patient use
- Development can be stopped at any time for cause (e.g. VIOXX)

Continuum of Testing of Military Systems: Objective

- Assure Adequate & Timely T&E Funding
- Materiel Solution(s) to fill "Capability Gap"
  - Early Operational Assessments
    - Effectiveness & suitability
    - Operational and technical risks?
- Development
  - Frequent assessment of progress
  - Test in realistic environments as early as possible
- Effectiveness and Suitability of *the entire system* after fielding
  - Lessons learned

Need Material Solution(s) for Capability Gap

- Early operational assessments of proposed solutions (M.&S.)
  - Input to design effort
  - Factors important in design
  - *Measurable* cost-effective improvements to mission capability (Evolutionary Acquisition)
  - Anticipate need for Dynamic Action by Blue to Red Adaptation

Modeling and Simulation for End-to-End System Evaluation: 1

- Size of budget & its allocation
  - Research and Development (R&D)
  - Prototypes; Developmental Testing, Subsystem Integration/DT
  - Developmental & Operational Test and Evaluation
  - Production & Procurement Costs
  - CONOPS
  - Sustainability; logistics
- Early analysis of schedule implications, including design upgrade, technology risk, and testing
  - If time requirement tight to field a block, the system more expensive (and slow) to field: problems found during OT&E, or worse, in the field (engineering design changes)
    - GEN Welch: “rush to failure” for THAAD
    - “If you don’t need it to work, I can ship it now”

Modeling and Simulation for End-to-End System Evaluation: 2

- Adequate developmental and operational T&E funding
- Preview system capability in an operational environment: Model
  - Unexpected vulnerabilities in effectiveness and suitability
  - Plan test design
    - Seed failure modes to be detected
- Preview test design
  - Use experience with similar systems
    - Government needs access to contractor performance data
  - Establish a DoD database containing lessons learned during system development
  - Red Threat
- *M&S Not a substitute for testing*: guidance

System Development and Demonstration

- Demonstrate system performance in its intended environment using competing prototypes
- T&E to assess technical progress for operational utility
- Early operational assessments
    - ID technology risks
    - Provide operational user impacts

DT results generally better than OT results

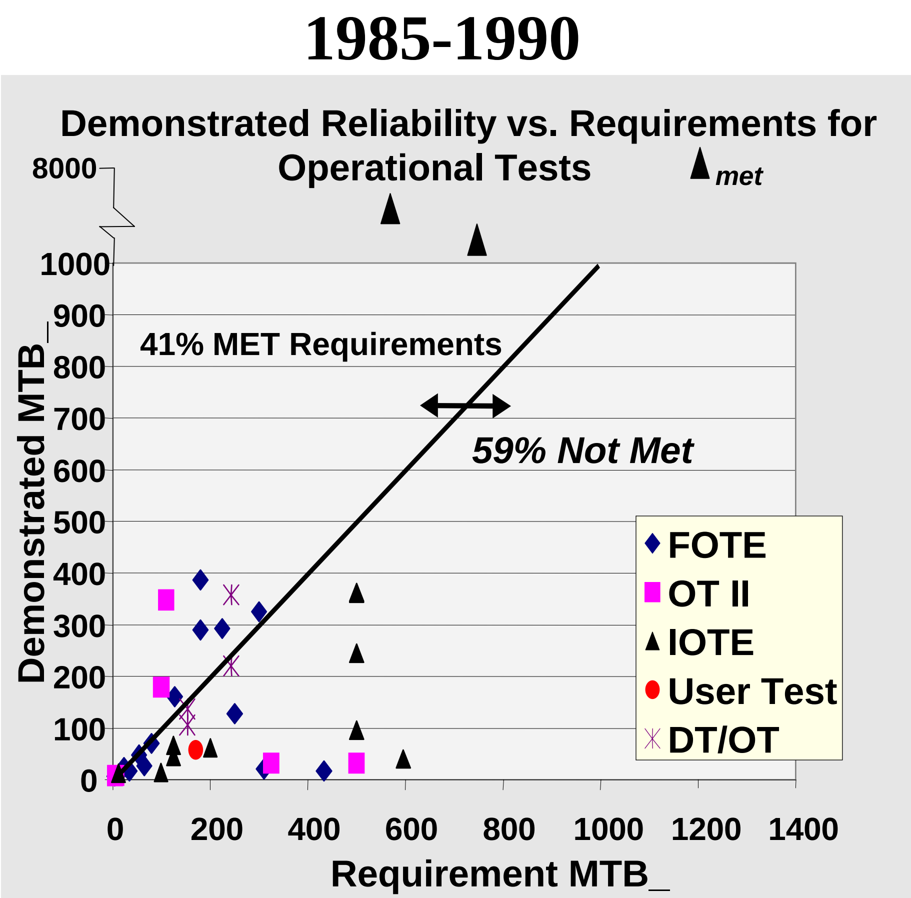
- “The PM’s rationale is that they will tell me that in past tests they have never had that problem before. Well, you never had that problem before because we, the soldier, use the equipment in the mud, and in the rain and we use it every day by the average soldier.”

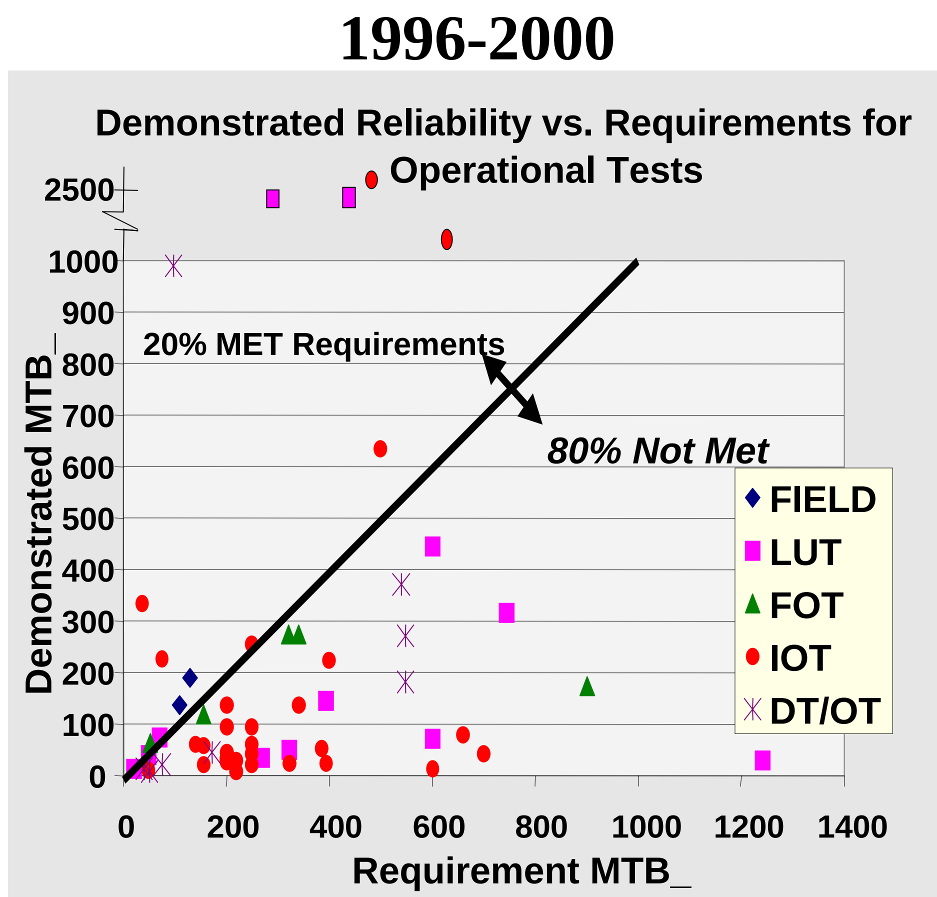
BG Honoré

1st CAV

Bring Mature Systems to Operational Test

- Systems fail because they are immature in design or manufacture, not (always!) because the fundamentals are bad





source: ATEC/AEC

Operational Testing

- ***EARLY*** (and Affordably Often) under representative real world conditions
  - Early discovery of problems permits fixes sooner & less costly; e.g. system weighs too much for (transport to) intended use in the field
  - Learn from training and exercise opportunities

Current Model

- Single-use system possibly containing design defects (DDs)
  – Each system used for one field mission
- Tests may discover DDs which are then removed (Reliability Growth)
  – Each remaining DD survives a test independently of previous tests
  – When DD activates during a test, the DD is removed (intention! Not always successful)
  – Test conditions→ Probability of DD test survival

Fixed Budget

- Includes
  - Testing & Removing discovered DDs
    - reliability growth
  - Buying copies for fielding
    - Copies may have DDs remaining
    - Remaining DD activates during field mission→ mission fails
    - Cost of modification
- Tradeoff:
  - Spend less on reliability growth→ can buy more systems, but it is more likely remaining DDs will activate during a mission (mission failure): redesign of the fielded system
  - Spend more on reliability growth→ can buy fewer systems but it is more likely a system will finish a mission without DDs activating

Design Defects (DDs) (Simplified Distinction!)

- Two types of DDs: DD1 & DD2
  - DD2s more difficult to activate during a test than DD1s
- When a DD is discovered during a test, it is removed

Tests

- Type 1 (Early)
  - Less expensive
  - Not as effective at activating DD2s; as effective at activating DD1s
  - Less expensive to remove activated DDs of both types
  - Can choose effectiveness of early tests
    - More expensive early tests are more effective at activating DD2s
- Type 2 (Late)
  - Expensive
  - More effective at activating DD2s (as effective at activating DD1s)
  - More expensive to remove activated DDs of both types

Learning from Testing

- Continue to do Early Tests until there are r1 Early tests in a row during which 0 DDs activated (r1 successful tests in a row)
  - Not learning more
- Then Late Tests until there are r2 Late tests in a row during which 0 DDs are activated
  - Not learning more
- Use remaining budget to buy systems for the field
- Choose r1 and r2 so as to maximize the mean number of fielded systems (missions) for which no remaining DDs activate

Number of Successes in a Row that Maximizes the Expected Number of Field missions in which No DDs activate (maximum run length=5)

Cost per Early Test	Prob. Surv. DD2 in One Early Test	Best Success Run Length: Early Tests	Best Success Run Length: Late Tests (more expensive)	Mean # Field Missions with 0 DDs activating
smaller	0.99 (less effective)	2	4	617
larger	0.85 (more effective)	5	3	726

Remarks

- More effective Early Tests →
  - Longer best run of successes for early tests (despite additional expense)
  - More reliability growth early
  - Fewer Late (more expensive) Tests
  - More field missions completed without remaining DDs activating

Example: Naval Special Warfare Rigid-Hull Inflatable Boat (NSW RIB)

- Close teamwork early testing: OPTEVFOR and combat users
- Competing Vendor Prototypes developed & tested until acceptance trials and source selection
- Early testing operationally realistic: OT&E completed in source selection phase before production contract
- All operational requirements met or exceeded during combined DT/OT
- Early reliability experience for NSW RIB much better than for craft it is replacing

Continuum of Testing

- Ensure adequate funding for T&E
- Provide operational insights throughout the development process
- Realistic testing environments as soon as possible
  - Mature systems to operational test
- Result: Field an effective and suitable system as early as possible and with less cost

746th Test Squadron

Innovate, Execute, Excel

Testing of the GPS SAASM End-to-End Functionality On Operational Weapons Platforms Without the Availability of the Signal in Space

U.S. AIR FORCE

13 March 2007

Jim Killian
746 Test Squadron
Holloman AFB NM

Integrity - Service - Excellence - Agility

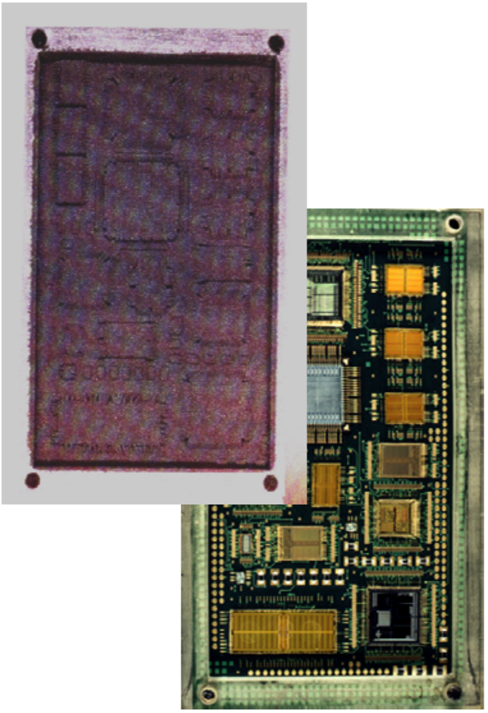
UNCLASSIFIED

Overview

- Background SAASM
  - What is SAASM
  - Status of Implementation
  - Test Capability Shortfall
  - Proposed Solution
- SAASM-ISER Test Set up
  - Concept
  - Components
  - Test Strategy
- Demo on Army HIMARS and Navy P-3
- SAASM-ISER Phase II Interfaces
- Benefits to the User
- Recap
- Questions

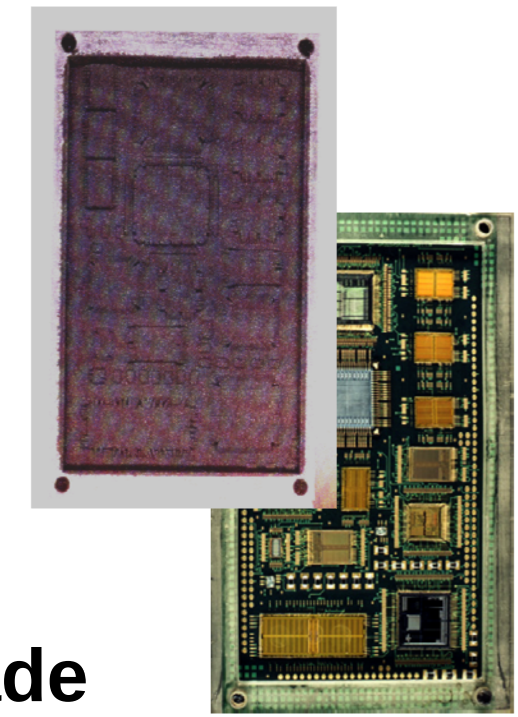
What is SAASM GPS?

- **New generation GPS Security Architecture**
  - **Extended functions**
  - **Black (unclassified) Keys**
  - **Over the Air Rekey (OTAR)**
  - **Anti-tamper design**
  - **Direct Y enabler**



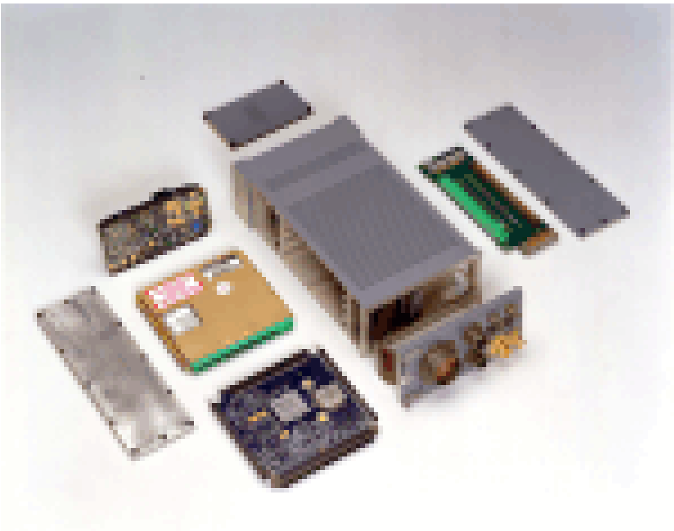
SAASM GPS

- **What does the User Get ?**
  - **Same Accuracy Performance**
  - **More Secure Military Ops**
  - **Simplified handling**
  - **More Capability**
  - **Over the Air Rekey**



- **Signal in Space (SIS) awaiting Master Control Segment upgrade**
  - **User and Space Segment ready**

SAASM Integrated Status



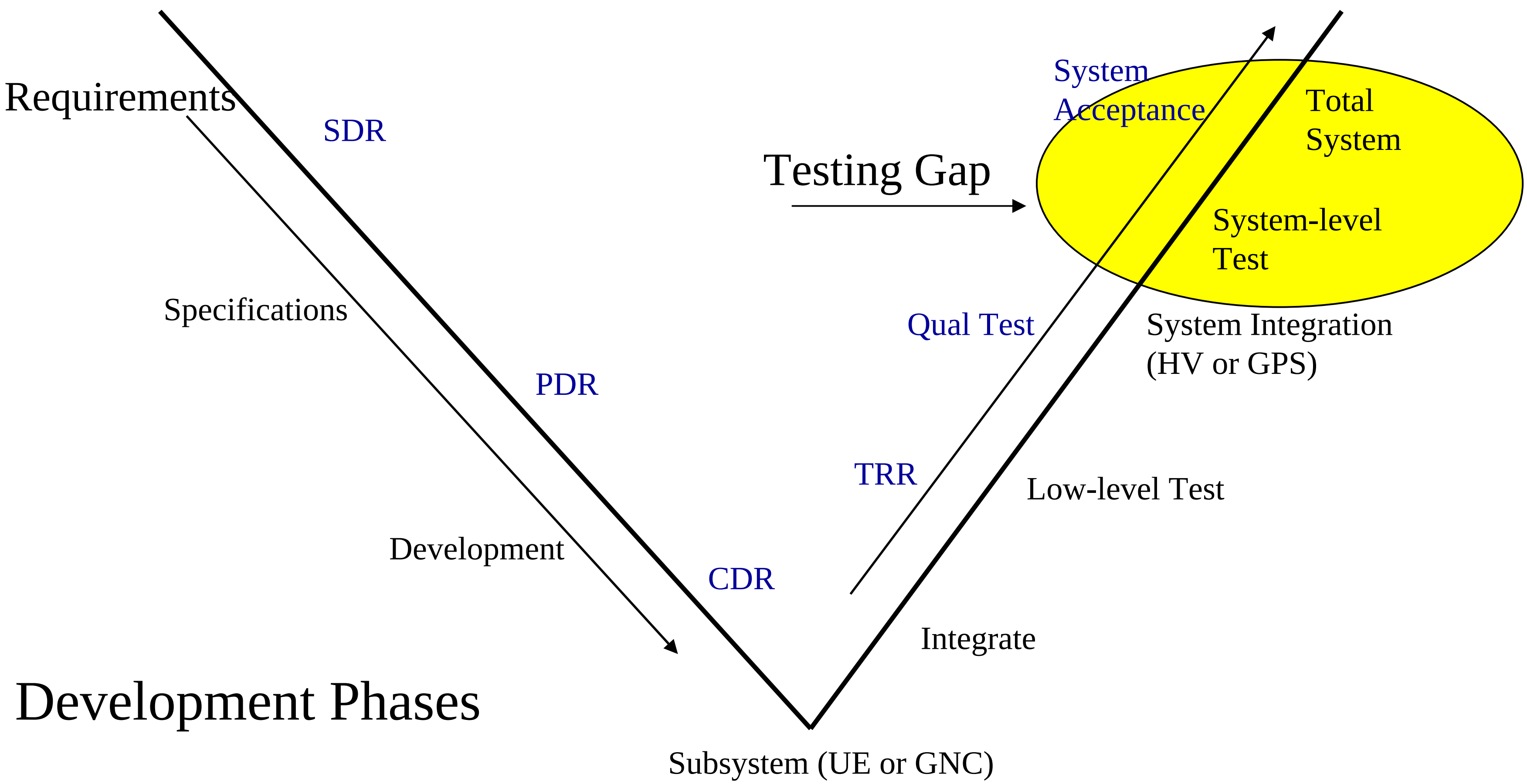
- Cards developed
- Integrated into box
- Integrated into systems
- Systems going operational
- SIS not available yet

Testing Gap

- **GPS SAASM cards are tested at the chip level, receivers are tested at the box level**
- **However, fully integrated system level testing was not being accomplished**
- **So, there is a Testing Gap of full functionality at the integrated system level**

Systems Engineering from Mission Need to Operational Part

- **MNS / ORD / CDD** **Operations**



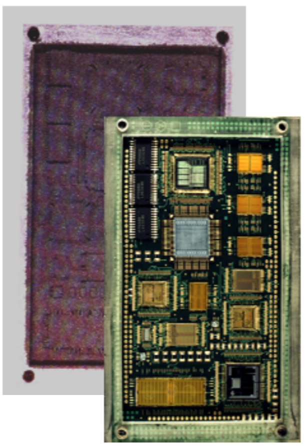
Lessons Learned

- **Most acquisition programs begin test phase with high level of confidence and optimism in the expected outcome, but…**

- **In practice most every test program experiences unanticipated ‘glitches’ that require correction**

SAASM Testing

CARD



BOX

?

INTEGRATED
SYSTEM

Problem

- **Platforms that use SAASM-based receivers cannot be tested easily at the system level**
  - **On-orbit signals are not yet available**
  - **Hard for operational platform to come to lab**
  - **Anechoic chamber testing is very costly**

Wait for SIS ?

- **Even with SIS a gap in test capability exists**
  - **Can't expect full functionality testing from SIS**
  - **Difficult to control scenarios during tests**
  - **Repeatable scenarios probably not available**
  - **Anomaly resolutions; lack the ability to duplicate specific conditions and signals**
- **Needed:**
  - **Capability to test before & after going operational**
  - **Ability to simulate and control all the SIS scenarios**
  - **Mobility to travel to the test platform**
  - **Connectivity - easy interface with various platforms**

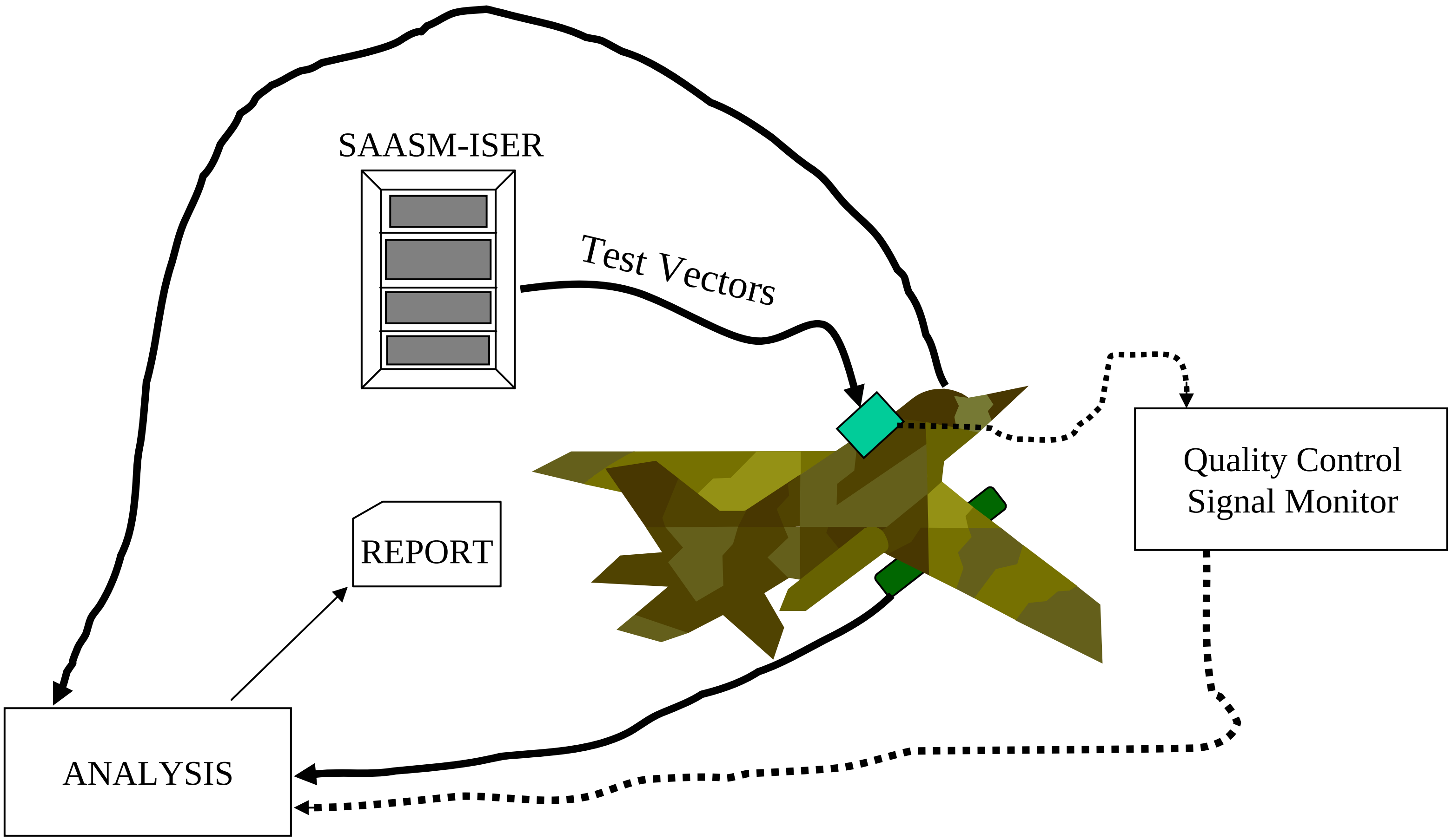
746 TS Developed Solution

- SAASM Integrated System Evaluator and Reporter - (SAASM-ISER)
  - Configure a precision GPS signal simulator to generate and exercise the extended functions on the SAASM-equipped platform
  - Make it a mobile test capability that can travel to the user's location; palletize and van equipped
    - Little to no down time on operational asset
  - Allow user's platform systems to be run unaltered in their operational configuration – antenna hood

Phase I SAASM-ISER Components

- **RF Hood (FRPA), GPS Simulator with PC NavTEL, Test Van**

SAASM-ISER Concept



Test Strategy and Approach

- SAASM scenarios and data collection requirements are coordinated with customer
  – Determine best scenarios, sequence, and data collection sources for SAASM-ISER tests
    - Scenarios are a subset of SAASM test vectors
  – Synchronize scenarios to platform test location
    - Consistent with INS geo-position and time
  – Test the hood for RF leakage prior to tests
    - Add shielding if necessary
  – Collect preplanned Data to include:
    - GPS State, Code Track, PVT, FOM, C/N_0

HIMARS Initial Demonstration

- Demonstrated first SAASM-ISER proof of concept and basic capabilities on the Army's High Mobility Artillery Rocket System (HIMARS) in 2005
- Desired test vectors successfully accomplished on a fully integrated and operational weapon system

HIMARS GMLRS

Antenna Hood

GPS Simulated signal scenarios are fed to test platform's GPS antenna and adjacent antenna tied to quality control monitor system to ensure signal integrity

Hood Mounted over 2 GPS Antennas

SAASM-ISER Test Van

- **Fully Equipped:**
  - **Elec Power Systems**
  - **Rack Tie-Downs**
  - **Dual Air Conditioning**
  - **Insulated**
  - **Climate Controlled**

Laptop Monitors,

DAGR

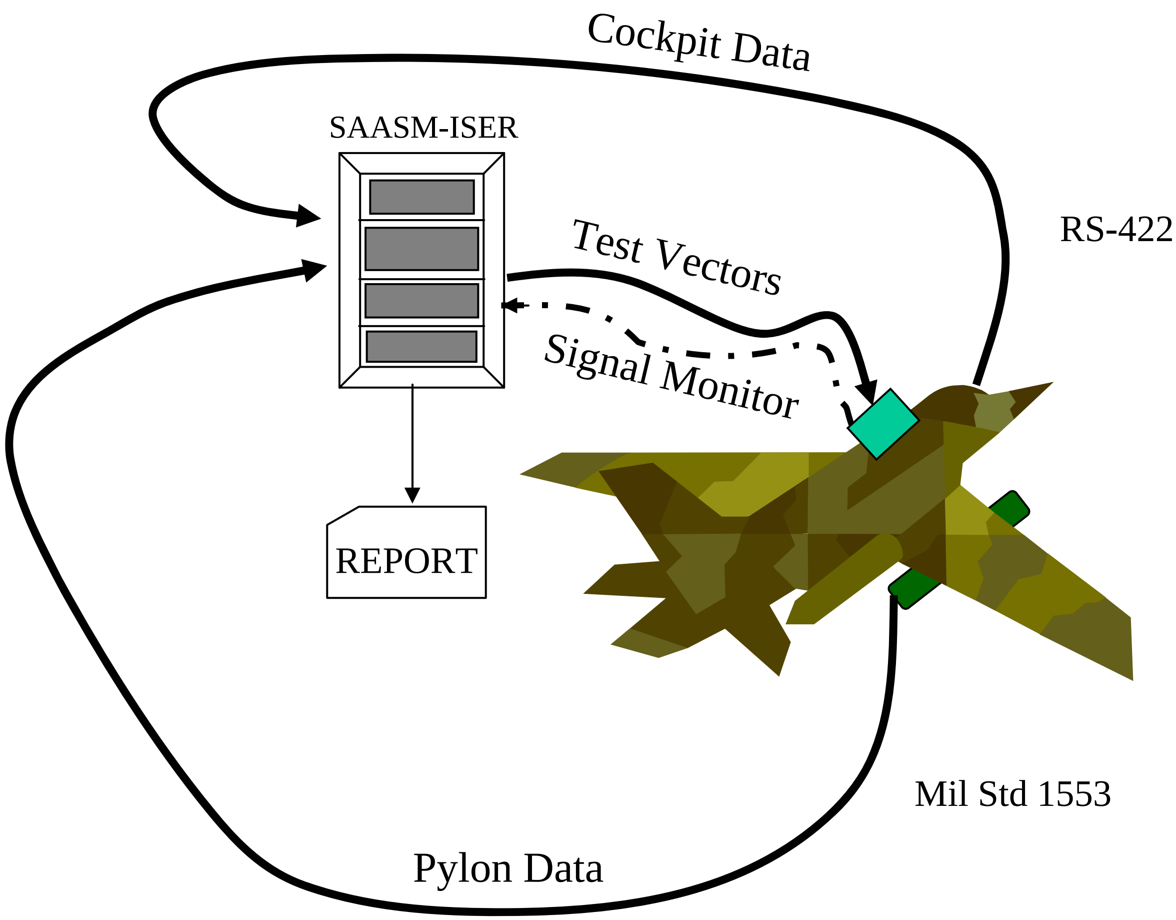
Signal quality and baseline monitor

Simulator

Navy P-3 Checkout

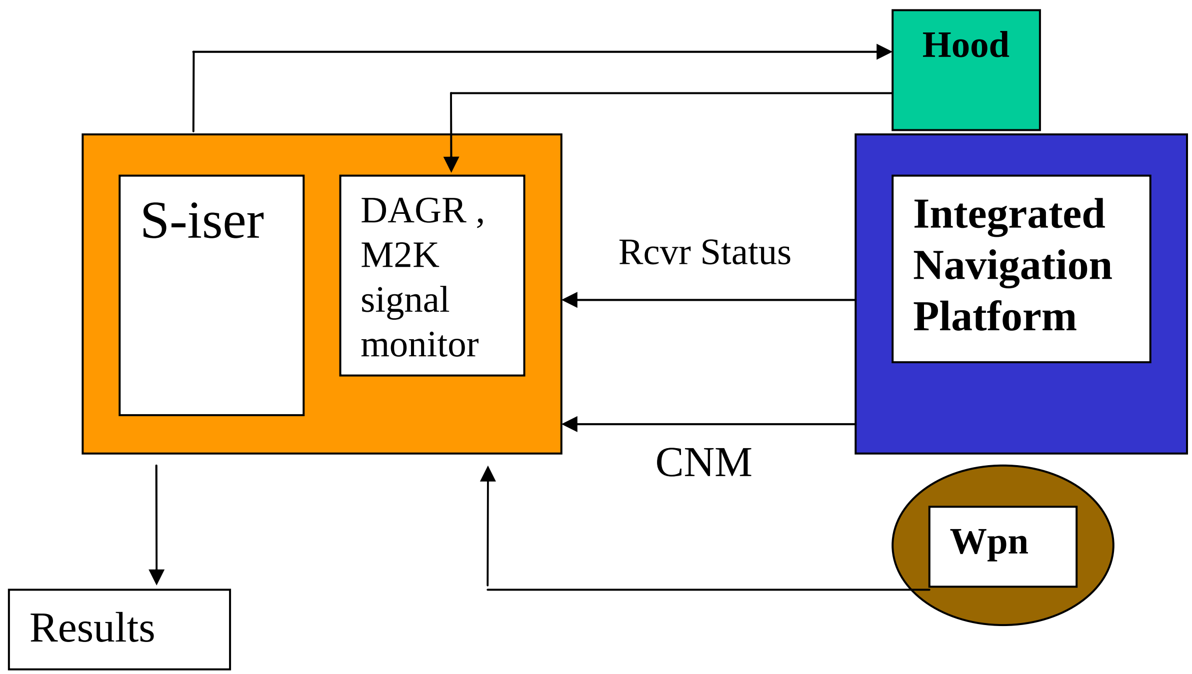
Performed SAASM and GPS RAIM tests on operational P-3 using SAASM-ISER

Phase II SAASM-ISER Concept



SAASM-ISER Block Diagram

- RF feed into platform antenna(s)
- RS-422, Mil-Std-1553, CDU data monitoring



SAASM-ISER

- Assessment methods:
  - Real-time assessment via cockpit displays
  - Data collected from receiver RS 422 Instrumentation Port
  - Data collected from platform Mil-Std 1553 bus
- Verifies integrated navigation system functionality of unaltered platform and weapon interface

What are the Benefits

- **Overall Benefits to the Warfighter are:**
  - **Reduces risk by substantiating technical performance prior to verifying system readiness**
  - **Resolves integrated system deficiencies early**
  - **Provides cost effective, short duration testing**
  - **Mobile - Can be performed on an operational platform at home station**
  - **Leverages 746 TS expertise in SAASM lab testing**
  - **Provides a means of anomaly resolution if needed**

Recap

- **SAASM- Integrated System Evaluator & Reporter**
  - **Fills a gap in the government's ability to perform end-to-end tests integrated SAASM systems**
  - **Provides for functional checkout of GPS SAASM extended functions on fully integrated weapons platform at low cost on home station**
  - **Provides means to duplicate/investigate anomalies**
- **SAASM-ISER Implemented on:**
  - **Army HIMARS**
  - **Navy P-3**
- **Follow on aircraft are in planning phase**

Questions?

Backup Slides

- Test Strategy
- HIMARS 3 Tier System
- Two FRPAs in Test
- Baseline Monitor
- SAASM-ISER Spirent, PC NavTEL
- Hood Detail
- Interface Cards

Test Strategy and Approach

- SAASM scenarios and data collection requirements are coordinated with customer
  - Determine best scenarios, sequence, and data collection sources for SAASM-ISER tests
    - Scenarios are a subset of SAASM test vectors
  - Synchronize scenarios to platform test location
    - Consistent with INS geo-position and time
  - Test the hood for RF leakage prior to tests
    - Add shielding if necessary
  - Collect preplanned Data to be collected include:
    - GPS State, Code Tracking, PVT, FOM, C/N_0

HIMARS Weapon System

- **CONSISTS OF THREE SYSTEMS INTEGRATED**
  - **Fire control system**
  - **Position / Navigation system (GPS / INS)**
  - **Launcher Weapon system (GPS / INS)**

Baseline Monitor

- **Baseline monitor antenna mounted next to platform's antenna. Feeds monitor SAASM receiver (DAGR)**

- **Baseline SAASM monitor ensures the quality of the signal and the scenario being used for the unit under test.**

SAASM-ISER Components

- GPS Satellite Simulator
  - Spirent STR 4760
  - Multi Channel GPS L1/L2, CA, P(Y) code
  - Generates GPS simulations
  - Certified by GPS JPO according to the Enhanced Validation Test Plan
- PC NavTEL
  - Provides real-time bus control, monitoring, communications and display of simulation
  - Exercises various models and test scenarios
  - Communicates with Spirent over a General Purpose Interface Bus (GPIB) interface

SAASM-ISER Components

- **FRPA RF Hoods**
  - **Metal Enclosure & RF Absorbent interior**
  - **Includes internally mounted FRPA radiator to provide simulated RF SAASM GPS signals**
  - **Signal is received by UUT antenna and separate monitor FRPA under the antenna hood;**

  1) **System-Under-Test antenna**
  2) **Baseline FRPA connected to DAGR**
     - **Provides baseline monitoring and quality control for signal integrity of SAASM-ISER scenarios**

SAASM-ISER Interfaces

- Interface Cards:
  - Mil-Std-1553
    - Common SAASM Interface Change Notice
  - RS-422
    - IP for ICD-GPS-150 type messages
  - Weapon Interface
    - Mil-Std 1760 connector

SAASM-ISER (Phase II)

- **Software module communications development**
  - RS-422 (Instrumentation Port data)
  - Mil-Std-1553
    - Common SAASM ICN (IFC-SJICWG-001) Provides "common" SAASM interface data to Smart Mil-Std-1760 Weapons
- **Test and Validate**
  - Conduct phase II tests on proxy system
    - MAGR2000-GS or SAASM-EGI in lab testing
  - Conduct analysis
- **Work with platforms on special requirements**

746th Test Squadron

Innovate, Execute, Excel

Testing the Latest Embedded GPS/INS Hybrid Navigation System for the F-16 Fighting Falcon

U.S. AIR FORCE

13 March 2007

Jim Killian
746 Test Squadron
Holloman AFB NM

Integrity - Service - Excellence - Agility

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Overview

- F-16 LN-260 EGI Test Item
- Approach and Test Methodology
- Test Capabilities Available at 46 Test Group
- LN-260 Overall Test Objectives
- Sequence Selected for Test Beds & Assets
- Truth Reference System to be used
- Summary / Lessons Learned / Conclusions
- Questions

F-16 Fighting Falcon

Integrated INS & GPS Navigation System for USAF and European Participating AF (EPAF)

- **Integrated Navigation system provides**
  - **Attitude**
  - **Navigation (PVT)**
    - **Position**
    - **Velocity**
    - **Time**

Current Navigation System

- **Separate GPS and INS units**

INS: Ring Laser Gyro Inertial Navigator

GPS: 5 Channel PPS Satellite Receiver

Kalman Filter

Blended GPS/INS PVT Solution

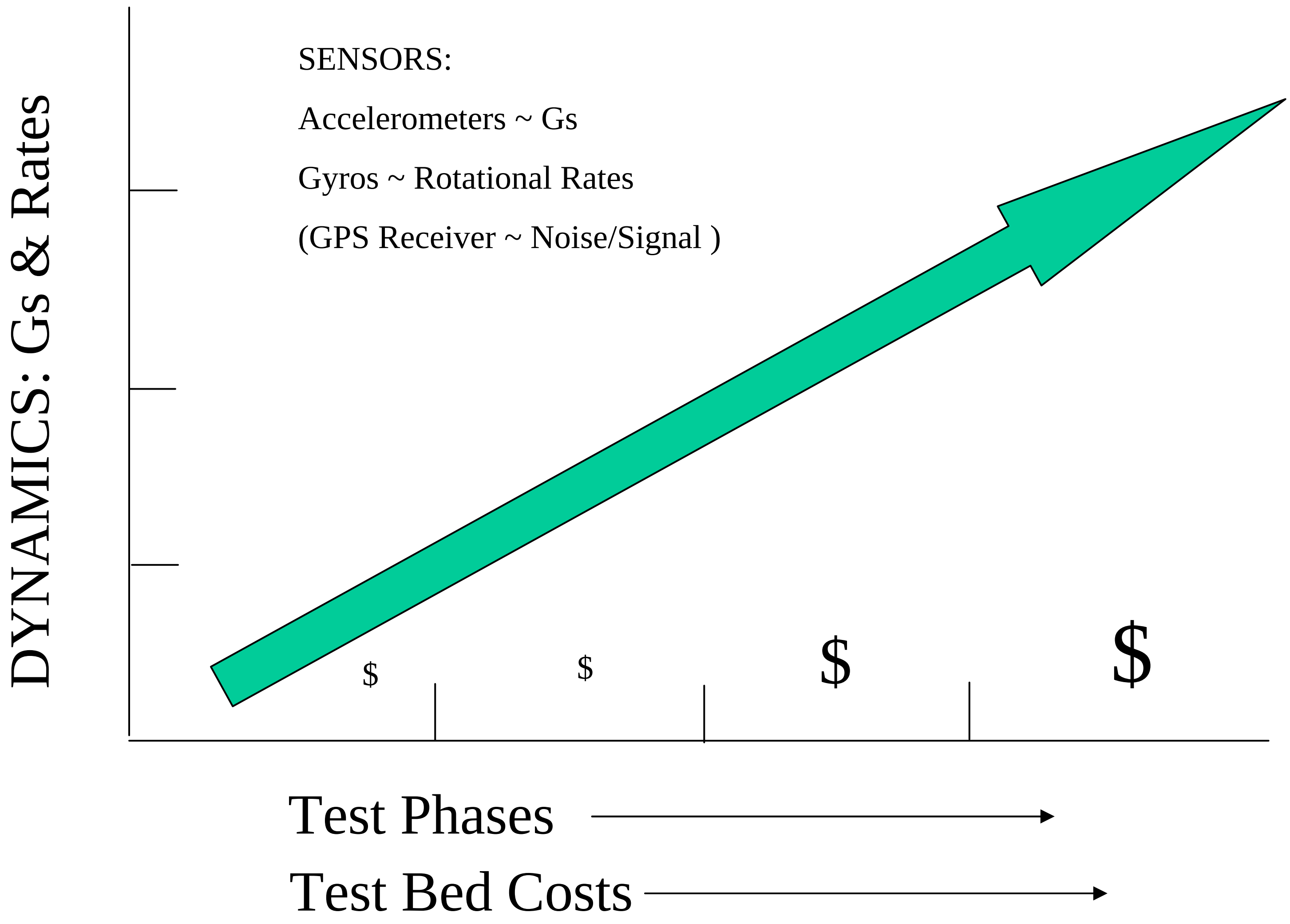
F-16 Hybrid Nav System

- **LN-260 NG Aircraft Navigation and Attitude**
  - **Inertial Navigation System (INS) < .8 nmi/hr RER**
    - **New Fiber Optic Gyros**
  - **GPS: RC GEM-VI, 24 channel L1 & L2 receiver**
  - **Single Unit; smaller size, weight, cost, power use**
- **Embedded GPS in INS (EGI), with Kalman Filter**

LN-260

- **Provides 3 separate solutions:**
  - **INS only, GPS only, Blended**
    - **'Tightly coupled'**
- **Same Performance ?**
- **Effective and Suitable ?**
  - **Requires T&E**

Notional Test Approach



Test Approach

Crawl - Walk - Run

Discover and correct issues early at a lower cost

Mature the system design

- **Methodically verify proper functionality of navigation unit**
  - **Physical and functional checkouts**
  - **Precision three axis table attitude and rotations**
- **Establish baseline performance**
  - **Benign, controlled, repeatable environment**
  - **Recheck as appropriate**

Test Approach (cont)

- **Performance and Characterization**
  - Gradually increase stresses on sensors and system to the specification limits while measuring performance in realistic profiles that are controlled and repeatable
  - The greater the dynamics and signal stress the more exposed existing problems become
  - Use state-of-the-art Truth Reference System

Test Location: 46 Test Group Holloman AFB NM

High Speed Test Track

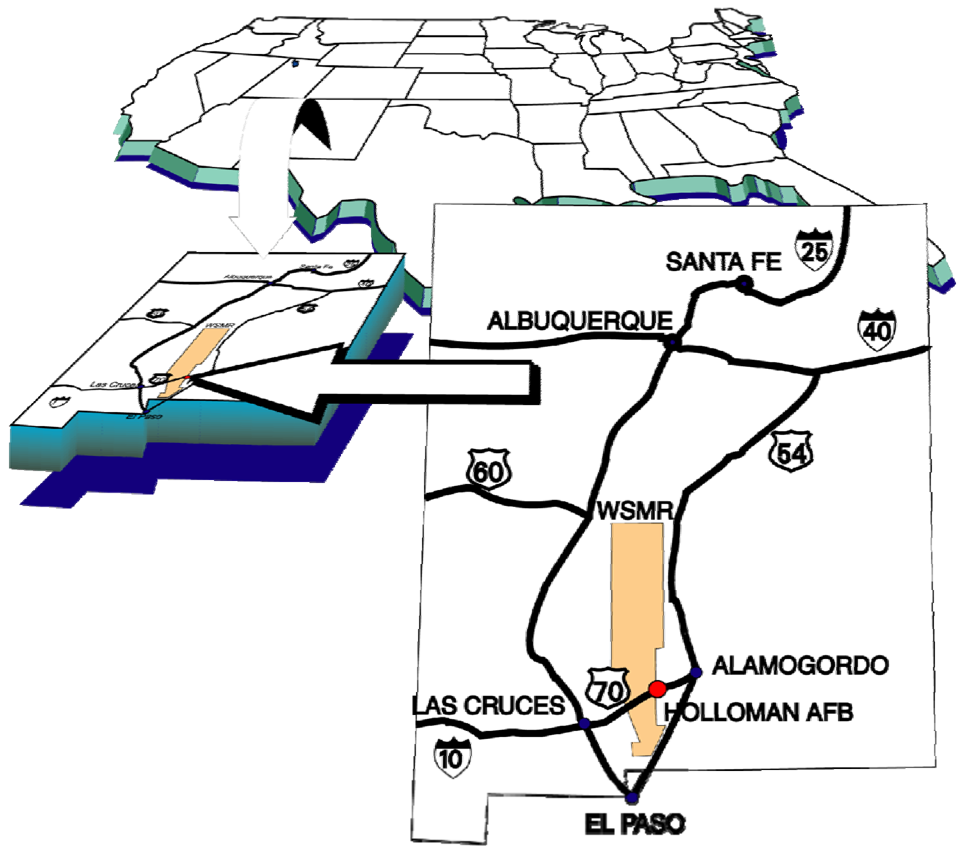
NRTF

Det-1

Flight Test

CIGTF

746 TS



- **State-of-the-art Test Capabilities**
- **746 TS; Central Inertial & GPS Guidance Test Facility (CIGTF)**

46th TG Test Capabilities

- **5 Test Squadrons within 46th Test Group**
  - **586 FLTS: Flight Test Squadron**
  - **746 TS: INS & GPS Guidance Test Squadron (CIGTF)**
  - **781 TS: National RCS Test Facility (NRTF)**
  - **846 TS: Holloman High Speed Test Track**
  - **Det 1: White Sands Missile Range Test Agent**

- **746 TS / CIGTF: Has complete range of GPS & INS Navigation and Guidance test capabilities**
  - **Satellite Ref Station (SRS)**
  - **Mobile SRS (MRS)**

Available Live Nav Test Beds

Dynamic Range Vehicles; Track, Van, Helo, C-12, Fighters


High Speed Precision Test Track


Land Navigation Vehicles

Helicopter

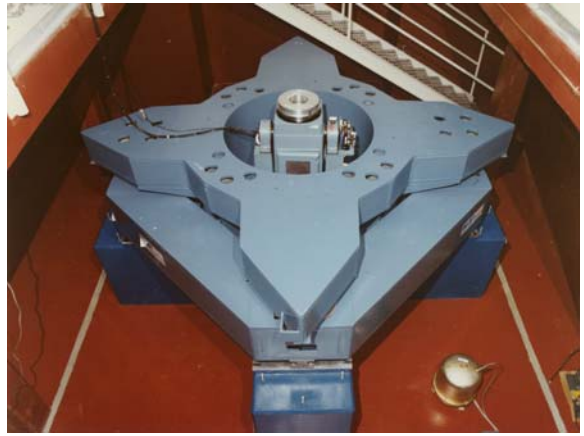
C-12

T-38

F-16, F15

Inertial and GPS Lab Facilities

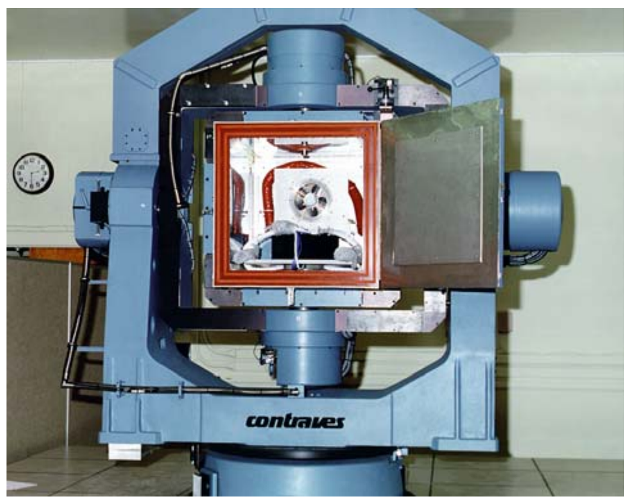
Advanced Inertial Test Lab



Seismically Stable Table

M&S Navigation T&E Lab

Precision 3 Axis tables



with Temperature Chamber

120” Precision Centrifuge

Test Objectives for LN-260 EGI

- Verify the F-16 LN-260 EGI performance complies with the published specifications and characterize significant aspects without specification
- Functional
  - Check physical, power and data properties
  - Demonstrate operation of interfaces and EGI modes
  - Baseline navigation outputs
- Performance
  - Evaluate the navigation performance under realistic operational and environmental conditions
- Characterization
  - Characterize calibration errors
- Areas of concern include effect of temperature, G and vibration on navigation performance

Test Bed Progression

- Bench top physical and functional checks
- Precision 3 Axis table position/rotations
  - 24 position tests at temperature variations
  - Inertial sensor calibrations

Low Cost

Preparatory

- Modeling and Simulation; NavTEL
- Van land navigation vehicle, low dynamics

Med Cost
Comprehensive
Controlled
environment

- C-12 cargo aircraft, low-med dynamics
- Precision 3 Axis inertial calibration recheck
- T-38 Fighter aircraft, med-high dynamics

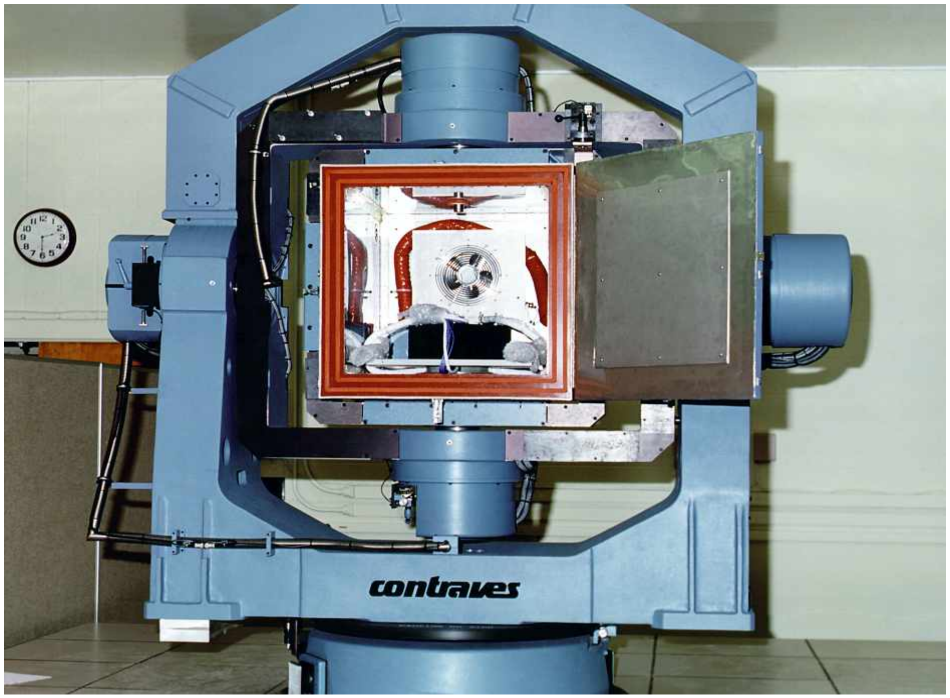
High Cost

Most realistic
environments

- Environmental: altitude, vibration, high G

Increased risk

3 Axis Rate Table 53Y

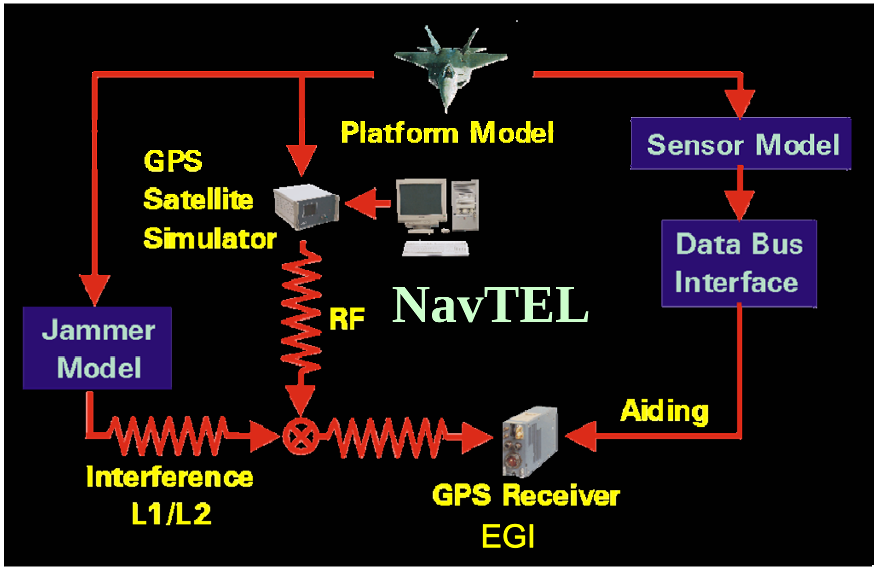


Precision 3 Axis: Position, Rotation, Temperature Tests

- Payload (200 lb)
- Accuracy (1 arcsec)
- Gimbal Rates (±750 deg/sec)
- Chamber (-55 to +85 deg C)

- Functional Alignment and Navigation
- INS Calibration Validation
-- 24 Positions (1g Environment)
-- Rotation Rates (20 deg/sec)
- Calibration / sensor baselines

Modeling & Simulation



-Controlled Signal Injection

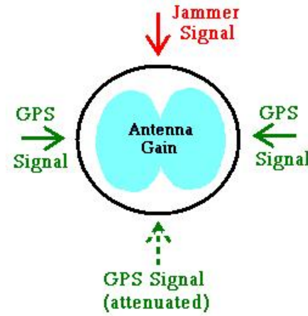
- INS & GPS profiles
- Models: Baro, Doppler, +
- Special Navigation Ops
- Jamming (broad scope)
- RAIM Integrity Monitoring
- SAASM Security Functions

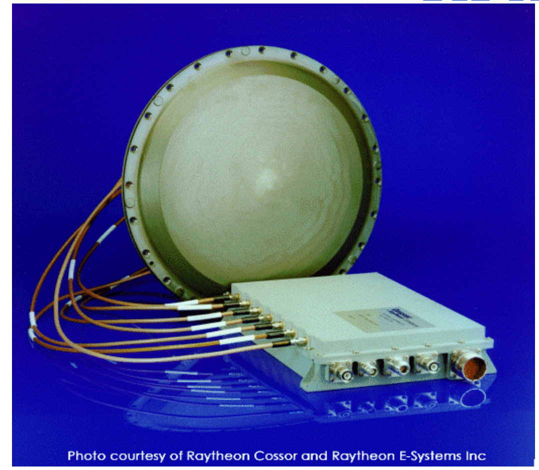
Navigation T&E Laboratory **(NavTEL)**

- Hardware-in-the-Loop Design
- Trajectories (Real & Simulated)
- Models: Sensor & Aiding, w/ Realistic Errors
- GPS Simulators (Spirent 4760 / 7700)
- **EGI** Simulator (CAST) Hybrid, > Fidelity
- Select Parameter Controlled On the Fly
- Interference Signal Generators (Jammers)
- Wave Front Simulator (Multi-Element Antenna Test)

CRPA Wave Front Testing

- Null Steering Antenna Tests
- Embedded Jammer Approach
- Jamming; up to 16 Sources
- Precise and Repeatable Tests
- Coherent Arrival Vectors, GPS and Jamming
- Controlled Signal Location, Timing & Phase

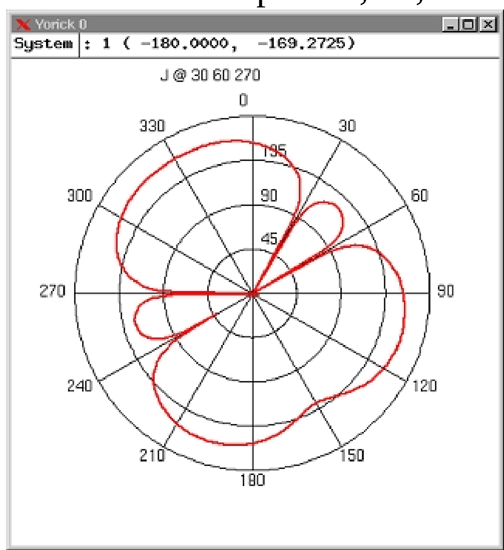




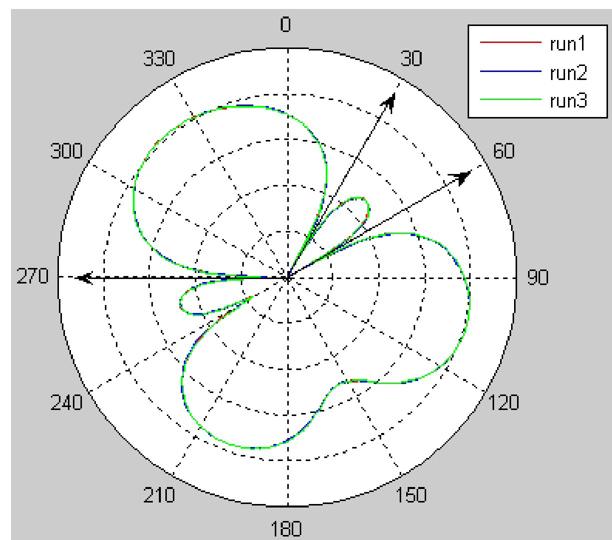
Controlled Reception Pattern Antenna

Coherent Wave Front Sim for GPS and Jamming signals

3 Jammer example: 30, 60, 270



Predicted Model



Measured Results

Operational - Live Performance

Low Dynamic Test	Medium Dynamic Test	High Dynamic Test
		

<ins>Land Navigation Vehicle</ins>
- Velocity (26.8 m/sec)
- Acceleration (1g)
- Navigation Modes
- GPS Jamming
- Precision Reference

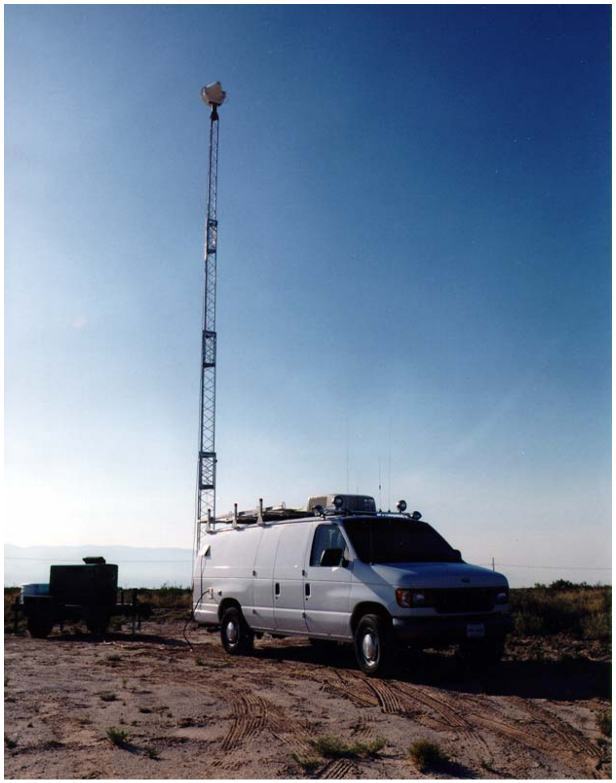
<ins>Cargo Aircraft (C-12J)</ins>
- Velocity (140-250 kts)
- Acceleration (2.5g)
- Navigation Modes
- GPS Jamming
- Precision Reference

<ins>Hi Performance (T-38)</ins>
- Velocity (Mach 1.1)
- Acceleration (7.2*g*)
- Air to Grnd scenarios
- Air to Air scenarios
- Precision Reference

Field Jamming Assets

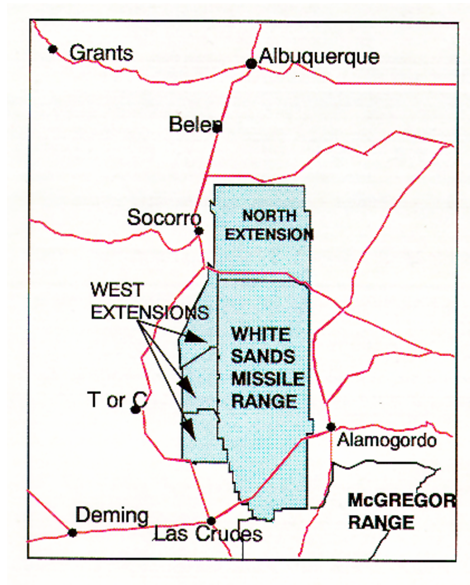
- **GPS Interference; Performance under signal stress**

Jamming Vans

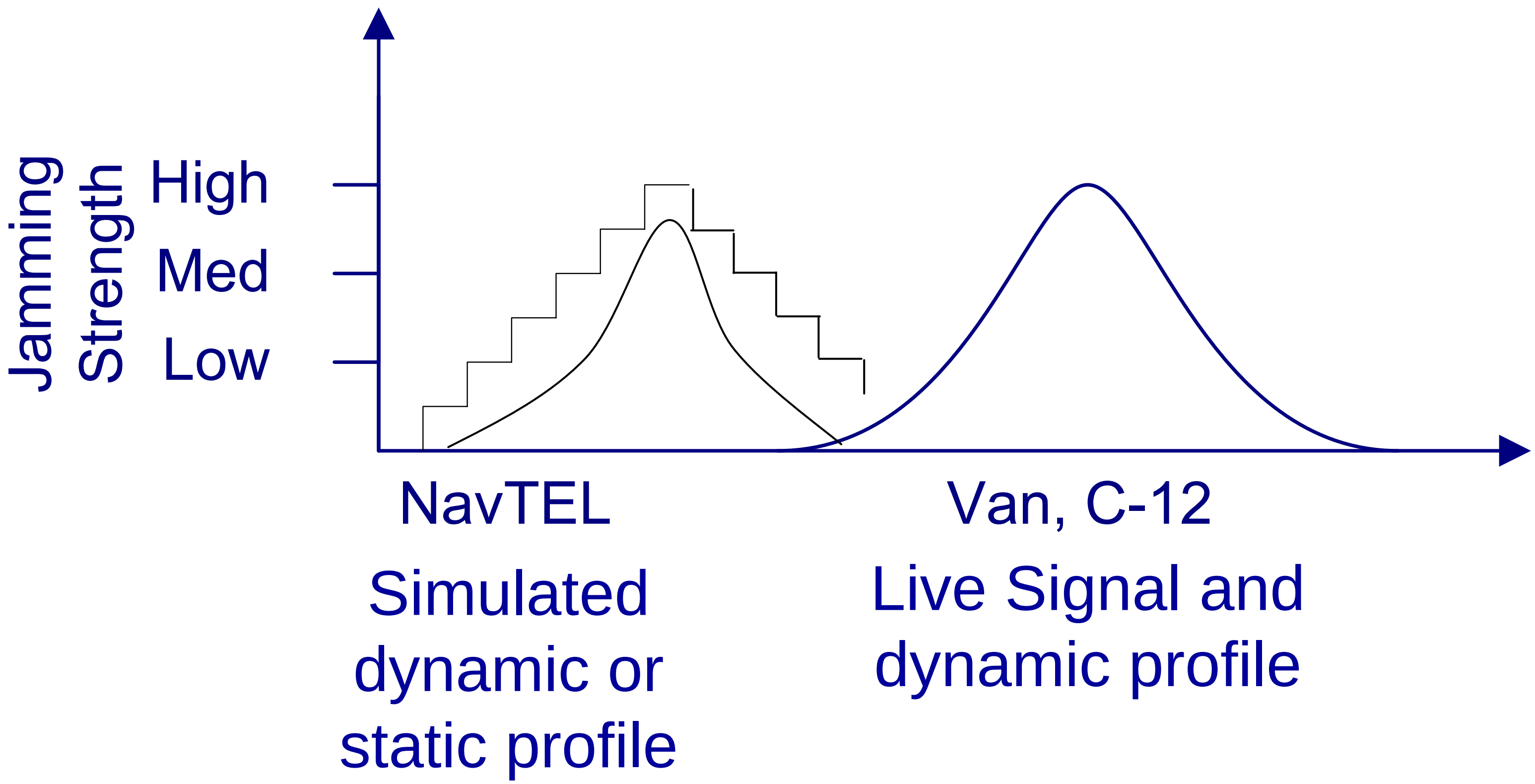


High Gain Antenna

WSMR Test Range



GPS Signal Jamming Stress



Environmental Lab Capabilities

- Test specification requirements not reached on previous test beds

Altitude / Temp Chamber

- Payload Navigating
- Pressure Altitude 80K' +
- 50-60K' planned
- Temp to match altitude
  -100 deg to +350 deg
- Humidity 5% – 95%

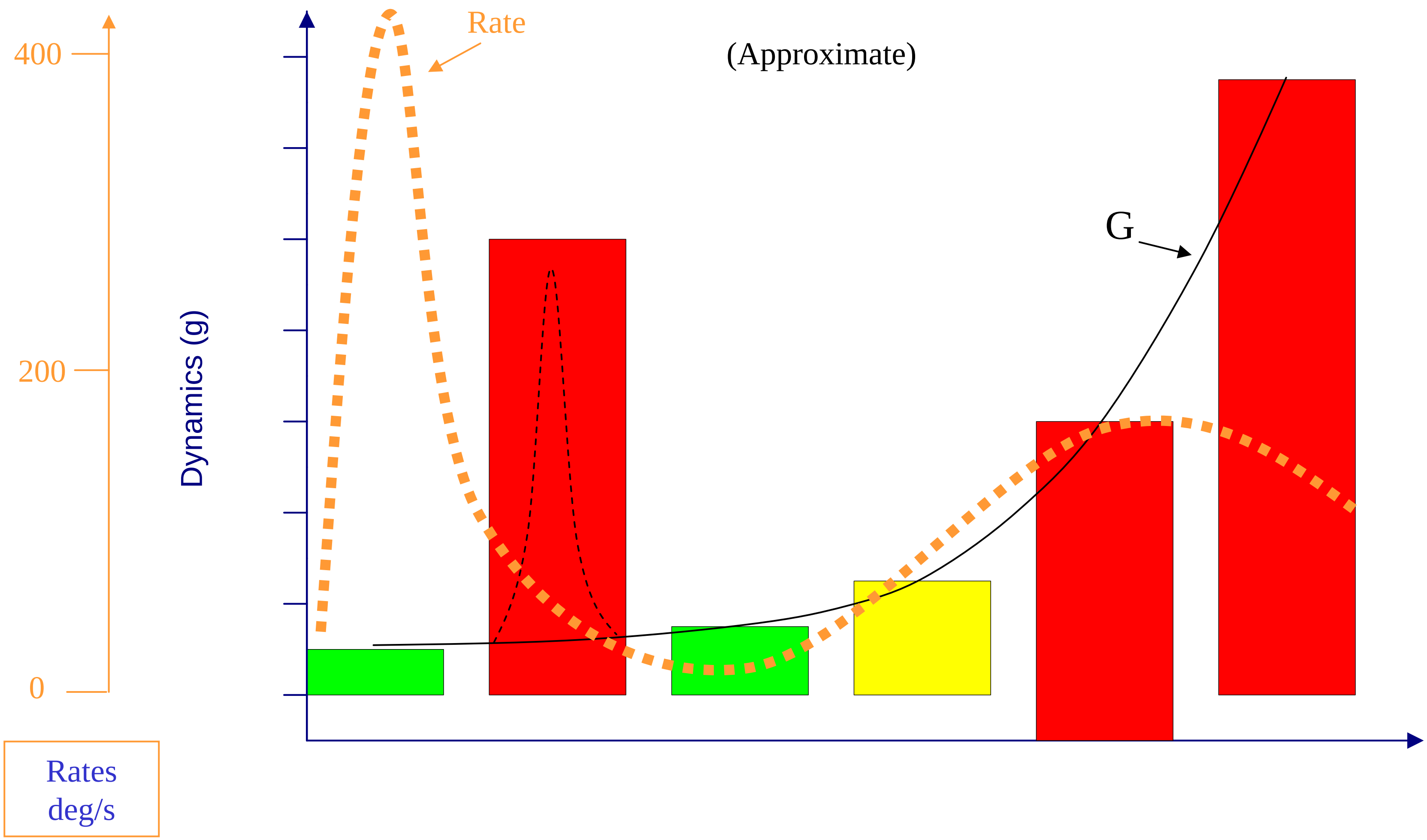
Vibration test beds

- Frequency/G controlled
- F-16 vibration profile
- M-60 Gatling gun
- Up to 1750 lbs force
- 2-2000 Hz (50#, 70g)
- 1 inch travel

Centrifuge 120" Radius

- Payload (100 lb)
- Accuracy (1 ppm)
- Acceleration (0.5 to 50 g)
- 13.5 g planned
- Test Item Fixture:
  - Fixed or
  - Counter- Rotating

Test Bed Gs and Rates



CIGTF Reference System (CRS) - Pallets

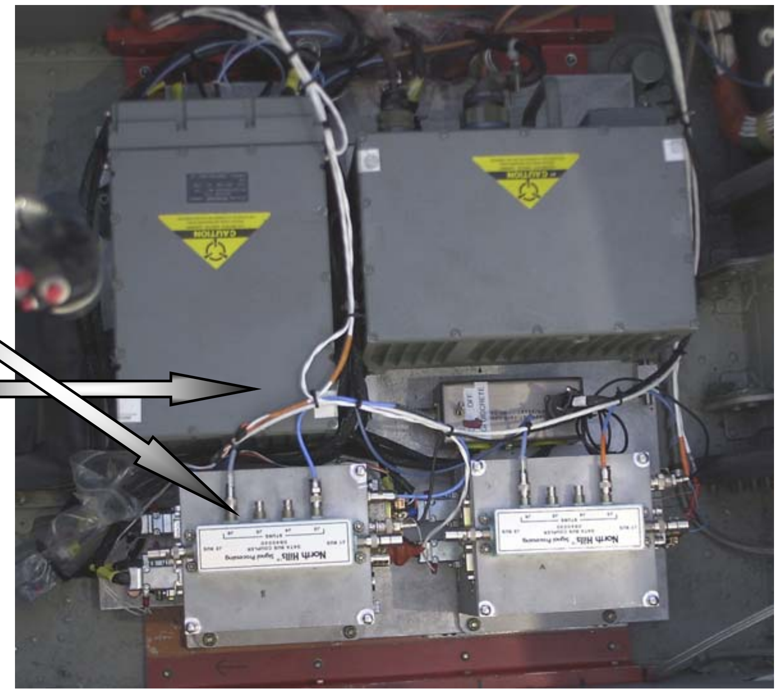
Rack Mount

(C-12J / Van)

DAS

EGI

Standalone



(T-38)

Fighter Inertial Navigation System (FINS)

Rack Mount (Development)

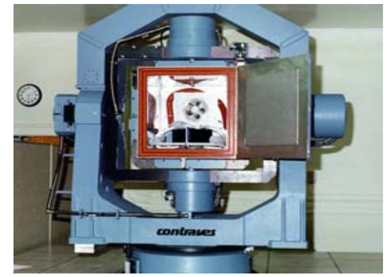
CRS - Subsystem Configuration Accuracy

[Subsystem] Configuration	RMS Position (m)		
	Horz	Vert	3D
[1] [2] GPS Code	**2.00**	**2.25**	**3.25**
[1] [2] DGPS Code [1]	**1.25<>1.75**	**1.0<>1.75**	**1.5<>2.5**
Carrier [2]	**0.30**	**0.20**	**0.35**
[4] RRS / *STARS* STS Absolute / Relative	**1.40 / 0.14** 0.071 / 0.0014	**1.00 / 0.10** 0.05 / 0.0010	**1.7 / 0.17** 0.087 / 0.0017
SRS Range Constraints: [1]300-500nm [2]50-100nm Differential GPS			

[Subsystem] Configuration	RMS Velocity (m/s)			
	East	North	Up	3D
[1] INS (EGI)	**0.010**	**0.010**	**0.010**	**0.017**
[3] INS (ESNU)	**0.005**	**0.005**	**0.005**	**0.010**
Attitude Accuracy: 20 arcsec (Roll, Pitch, Heading)				

SUMMARY

- CRAWL
  - Benchtop physical and functional tests
  - 53Y 24 precision position, attitude and rotations
  - Baseline performance for inertial portion



- WALK
  - NavTEL Modeling & Simulation
  - Van 2D low dynamics, low rates
  - Baseline GPS, INS and Hybrid solutions

- RUN
  - C-12, 3D med dynamics, med rates
  - T-38, 3D high dynamics, high rates

- Environmental
  - Centrifuge; Altitude chamber; Vibration profiles
  - Higher risk and stress modes

Lessons Learned

- **Often PM tendency is to streamline the T&E phases due to Cost and Schedule pressures**
- **Testing WILL find unanticipated problems, guaranteed.**
- **A thorough and systematic government independent T&E approach will actually reduce ultimate cost and schedule by finding/correcting problems early**
  - **"Rely on Independent Government Test"**
  - **"Focus on Performance"**

  (Words of Gen Randolph, JNC 2004)

CONCLUSION

- **Follow well planned graduated test approach that manages risk and finds and fixes problems early**
- **Avoid cutting plan to save time or $, which often increases Cost and Schedule.**
- **Thorough Benchtop and 3 Axis table tests are valuable in uncovering problems early, prior to van and flight testing**
- **Match tests to realistic environment as practicable**
- **Apply increased stress in a controlled fashion**
- **Place high risk tests at the end to reduce possible early schedule impacts due to system failure**

Recap

- **LN-260 EGI**
- **Wide range of test capabilities in house**

- **Benefits of selected order**
  - **"Crawl, Walk, Run"**
  - **Facilitates testers familiarity with test item**
  - **Establish Baseline performances**
  - **Comprehensive; identify & isolate problems early**
  - **Risk managed to reduce 're-fly' schedule impact**
  - **Mature system design in most cost efficient method**
  - **Continuity with same team of experts throughout**

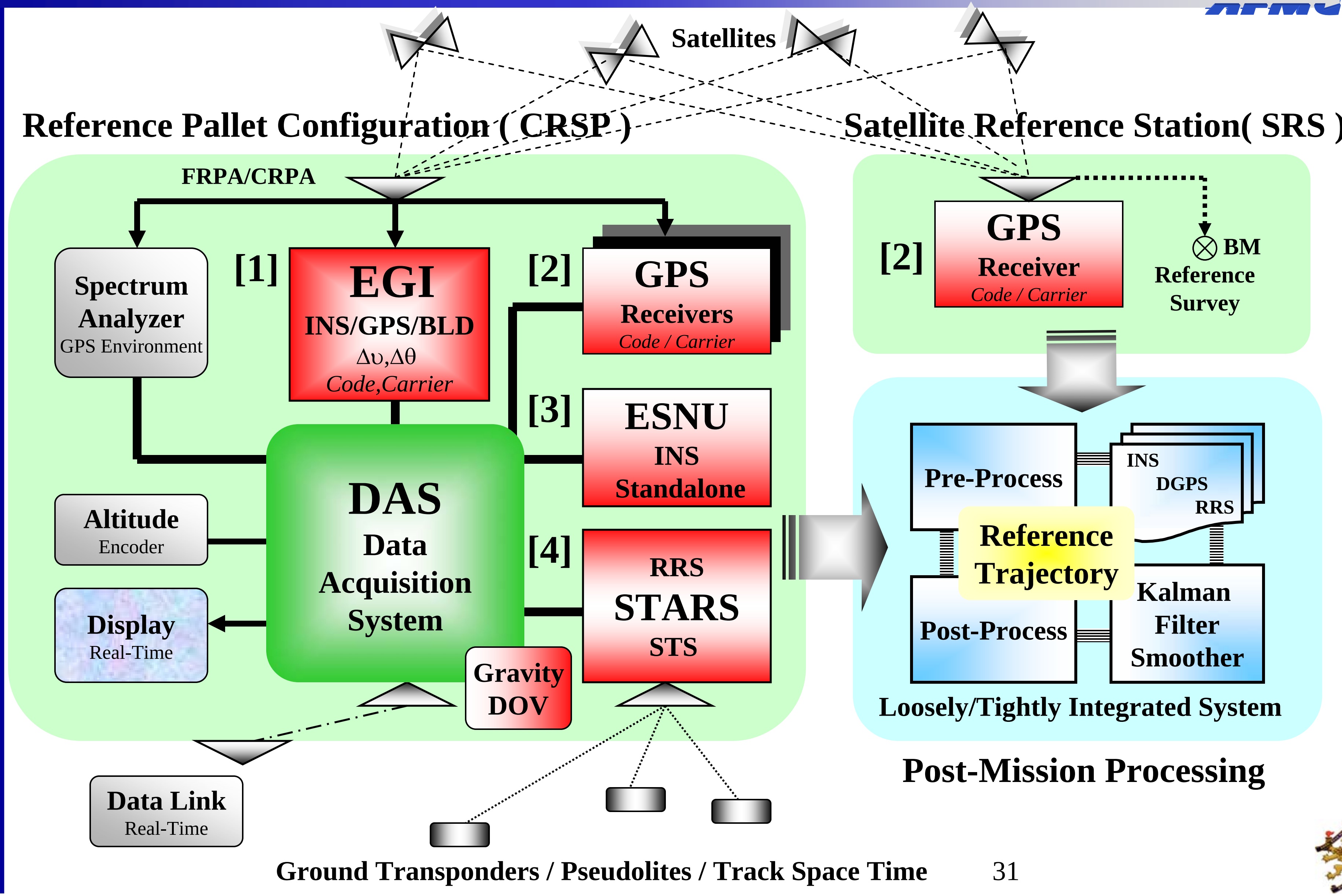
All to support the Warfighter

Questions?

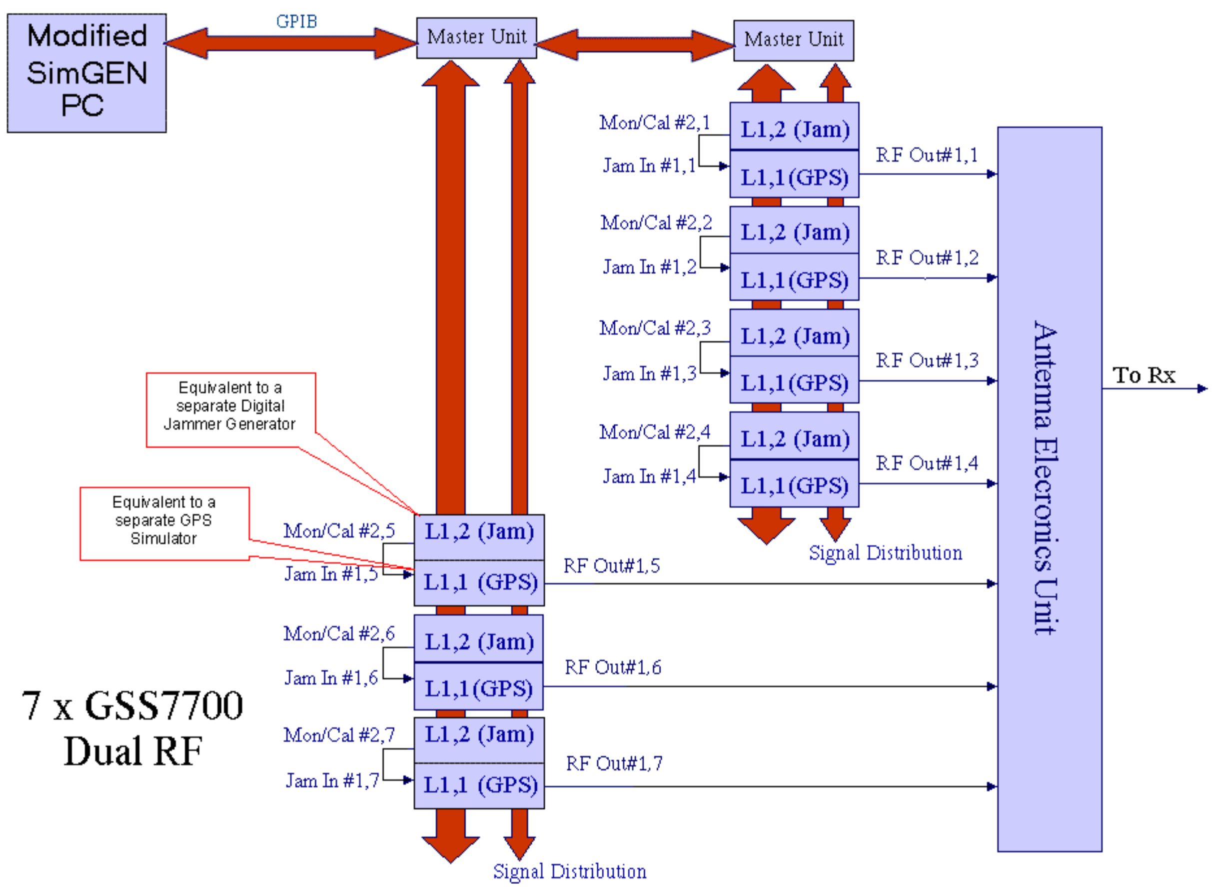
Back Up Slides

- CIGTF Reference System Block Diagram
- CRPA Wave Front System Block Diagram

CIGTF Reference System Architecture



Wave Front CRPA Simulation



Backup Slide

23rd Annual NDIA

National Test & Evaluation Conference

Sustainment of the Deployed Navy Munitions Inventory through continuous Quality Evaluation Test and Evaluation

March 14, 2007

Jeffrey L. Johnson
Director, Navy Quality Evaluation Program
Naval Ordnance Safety and Security Activity
Indian Head, MD 20640-5555
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Naval Ordnance Safety and Security Activity Quality Evaluation Program

- Provides an independent assessment of the continued safe and reliable performance of in-service weapons through routine and continuous testing
- Quality evaluation testing is the method used to predict and therefore prevent munitions failures that are inherent in their design or are the result of aging
- Provides a significant contribution in assuring that the Fleet is not the first point of detection of catastrophic failures
- Predicting failures and degraded performance is necessary to ensure that Fleet readiness can be assured throughout the reprocurement cycle

Quality Evaluation Program Objectives

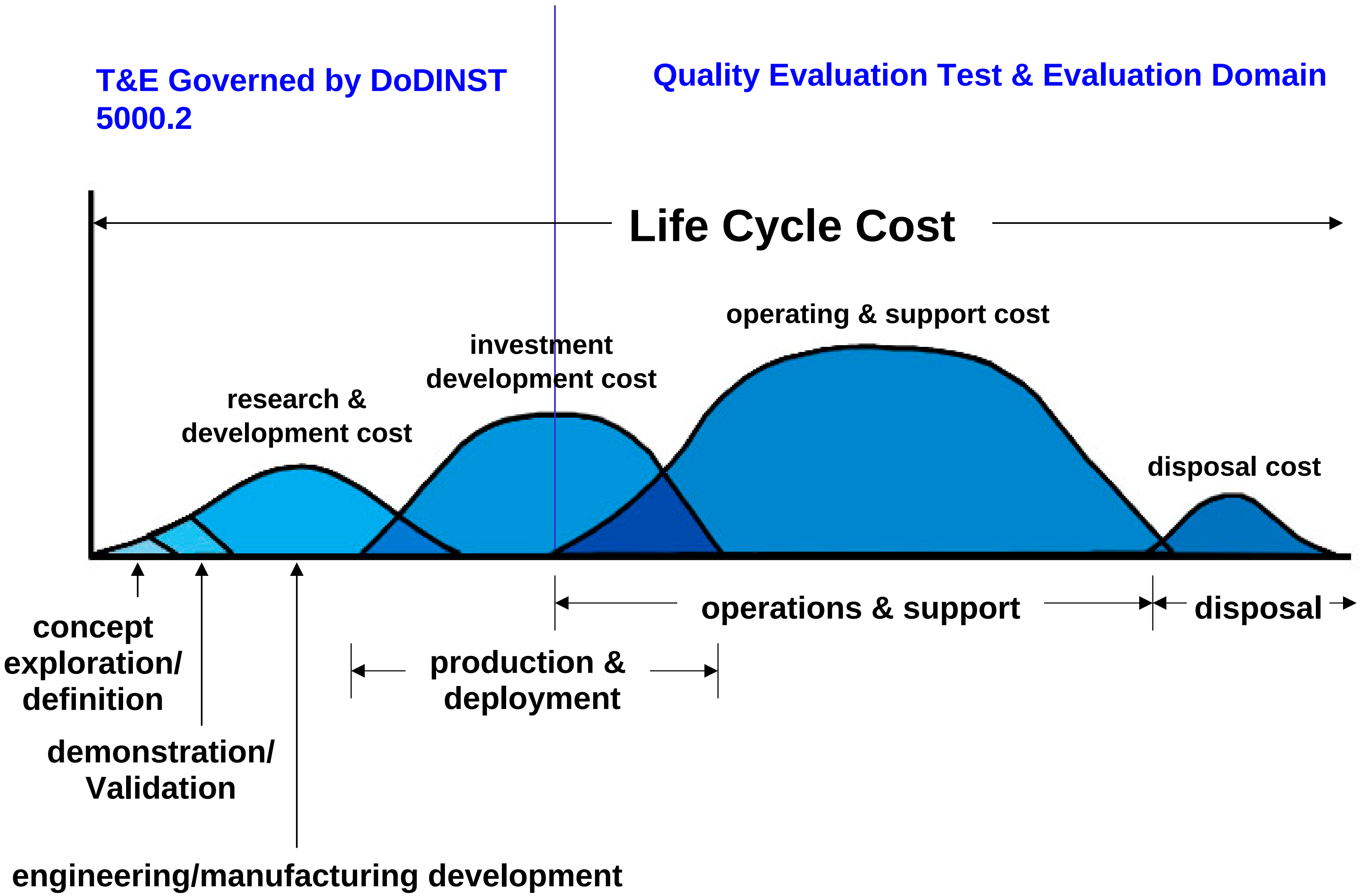
- Assess the safety, reliability, & performance of the Navy weapons arsenal
- Identify and monitor critical characteristics that change with age and exposure
- Detect performance changes related to age and service use
- Predict future performance and service life/service limitations

Quality Evaluation Program Domain

- **All in-service Navy weapons and ordnance programs**
- **In-service inventory - currently valued at $40B**
- **Overall age of inventory is 15 – 20 years**

Ordnance Safety & Security Activity

Life Cycle Test & Evaluation vs. Life Cycle Cost



Quality Evaluation Program Contributions

- Condition should drive maintenance
- Provides objective and independent test and evaluation of deployed munitions
- Identifies potential performance degradation during the operational phase
- Provides assurance that lethality, reliability and safety is retained in the operational phase
- Predicts the effect of system degradation of life cycle readiness and logistics issues

Ordnance Safety & Security Activity

Life Cycle Readiness and Logistics Impact of Aging and Exposure

- **Degradation of reliability and performance characteristics critically affect lethality and P_k**

- **Inventory requirements depend on computational methods using as-built P_k without regard for degradation of the deployed inventory**

- **Relying on as-built reliability and performance to determine the quantity of weapons needed to meet mission objectives overlooks the effect of degradation trends understates actual inventory requirements**

Typical War Fighter Concerns

- **Is normal use/consumption still possible without risk to the user after the ammunition is exposed to field conditions?**
- **Does returned ammunition have the same capability as "normal" ammunition?**
- **Are the minimum conditions under which ammunition is currently tested & evaluated during development sufficient for service use in an operational environment?**

Typical War Fighter Concerns (Continued)

- **Will it be necessary to define restrictions for operational use to ensure in-service safety?**
- **Does Ammunition Surveillance ensure unrestricted use, or should special field conditions and mission time be taken into consideration?**
- **Can undesirable changes to the ammunition be avoided by providing special storage conditions (air-conditioned containers or other storage modules)?**

Traditional Aging Studies and Predictive Analysis

- Traditional approach relied on destructive testing of meticulously selected test samples
- Limited sample sizes creates potential for statistical error
- Aging studies discover abnormalities caused by aging factors
- Studies provide basis for risk assessment and important retain/discard decisions

While the confirmation of operational suitability of inventory weapons has traditionally been left solely to real time testing it is likely that greater understanding of the explosive material degradation mechanism through aging studies and predictive analysis, will result in a more accurate and cost effective ability to forecast the limits of continued operational suitability.

Quality Evaluation Program Technical Desires

- Condition-based maintenance
- Increased availability of life-cycle T & E information
- Health monitoring
- Aging studies and predictive analysis
- Modeling and simulation

NAVSEA
NAVAL SEA SYSTEMS COMMAND
Ordnance Safety & Security Activity

Increased Availability of Life-cycle T & E Information

- Operational testing and maintenance data
- Fleet training results including telemetry data
- Improved and integrated data bases and data analysis tools
- Zero-age performance data including the results of chemical and physical analysis

The ability to collect and integrate information from production acceptance, testing, training, environmental exposure, maintenance and handling, and forensic laboratory examination of failures will assure that predictions reflect the most significant and compelling estimates of the continued performance and safety of explosives-based munitions.

Health Monitoring Approach

- Integrated maintenance and failure-reporting data systems
- Adoption of standardized/adapted best-practices across systems
- Failure and assessment modeling toolbox
- Development and deployment of micro-electro-mechanical (MEMS) sensors
- Remote collection of real-time location data and environmental data
- Labor-free monitoring of environmental conditions
- Determination of failure liability and the applicability of warranty coverage

There is unquestioned degradation of munitions, most specifically explosive and energetic material but also to electrical components, due to chemical changes and the effects of environment. It therefore logical that we have the ability to non-invasively monitor these degradation patterns.

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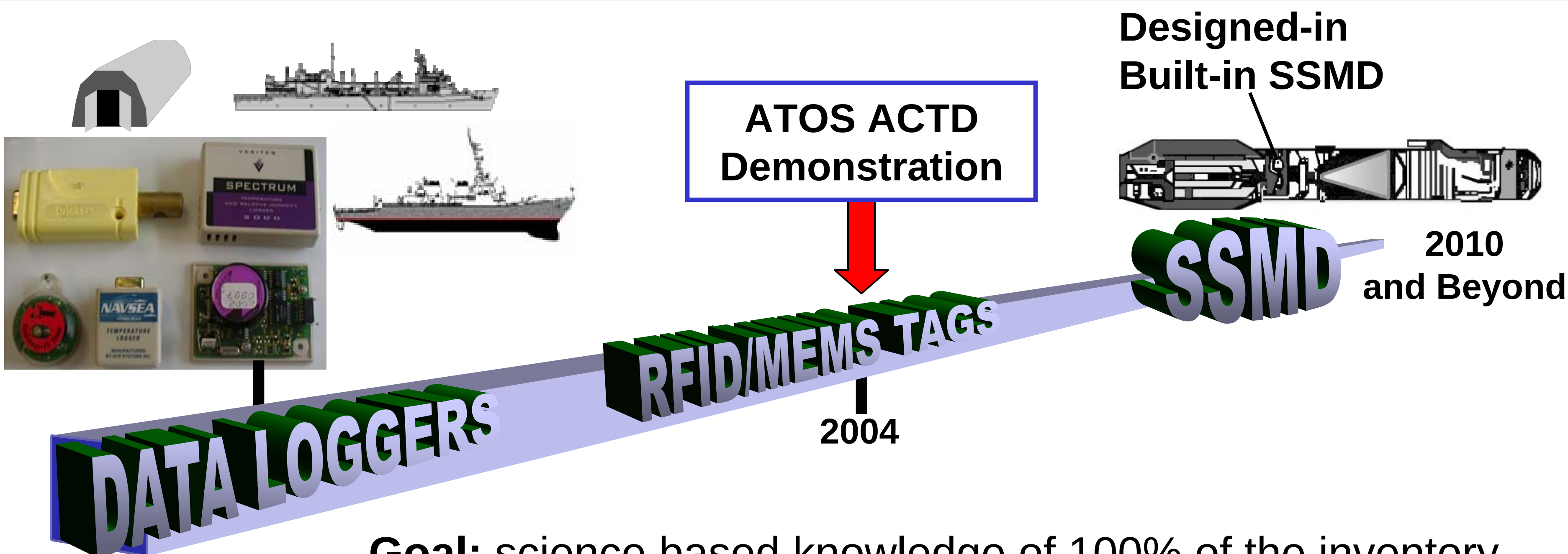
Evolution of Microelectromechanical (MEMS) Sensors



Goal: science based knowledge of 100% of the inventory, 100% of the time, via 100% non-destructive means

Maximized self-sensing and monitoring devices (SSMD)

Increased use of non-destructive technologies and modeling/simulation techniques (100%)

Reduced non Fleet-training destructive testing

Modeling and Simulation

- **Models are needed to assess reactions to multi-variables such as temperature, humidity, vibration, shock**
- **Simulation of aging effect will permit understanding of resulting changes**
- **Understanding of changes will permit determination of remaining safe and useful service life**

The knowledge needed to assure success include the development of simulation models that will permit the understanding and characterization of the effects of aging and environmental forces that includes environmental variables and combinations of currently used oxidizers, stabilizers, double and single base propellant configurations, particle size, case bonding methods, process variables and grain geometry.

Conclusions

- Objective and independent life cycle test and evaluation of in-service weapons are necessary to assure weapons meet operator needs throughout service
- Maintenance and re-procurement plans should be based on how well the systems meet requirements
- Test-until-failure analysis is giving way to the analysis of degradation forces using aging and environmental exposure simulation models
- Real-time self-sensing monitoring systems will contribute to the quantification of aging effects and the reliable determination of remaining service life
- Standard M & S tools will be relied on for the assessment of the effects of degradation caused by aging and environmental exposure on the continued safety, performance and reliability of in-service munitions

NAVSEA NAVAL SEA SYSTEMS COMMAND
Ordnance Safety & Security Activity

OUR GOAL: FAILURE PREVENTION

Naval Sea Systems Command

NUWC Division Keyport

ESMS

(Event Streaming Media System)

A tool for media synchronization and T&E insight

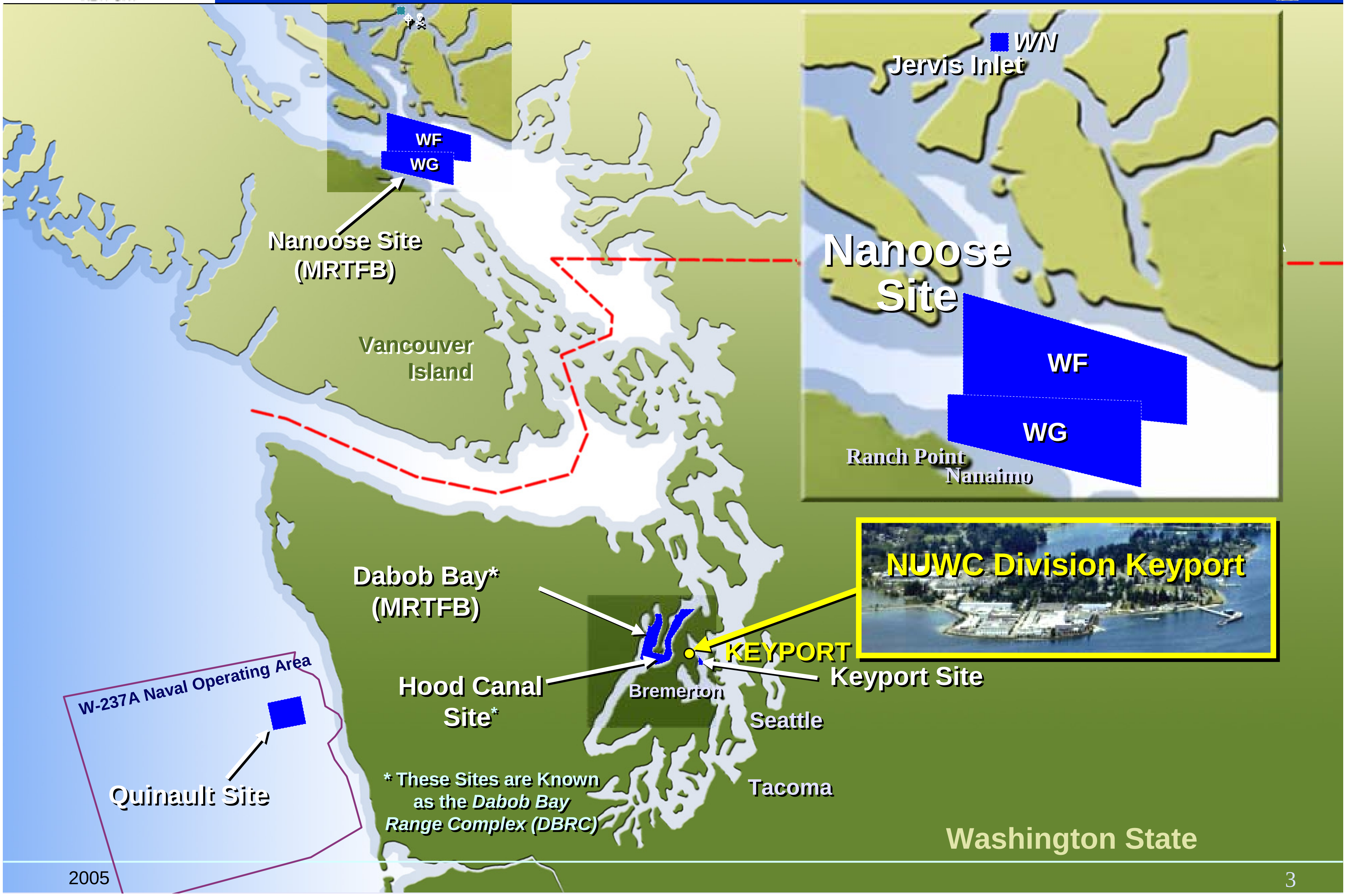
Presented By:
Reid Johnson
ESMS Project Engineer
360.396.6658

14 March 2007

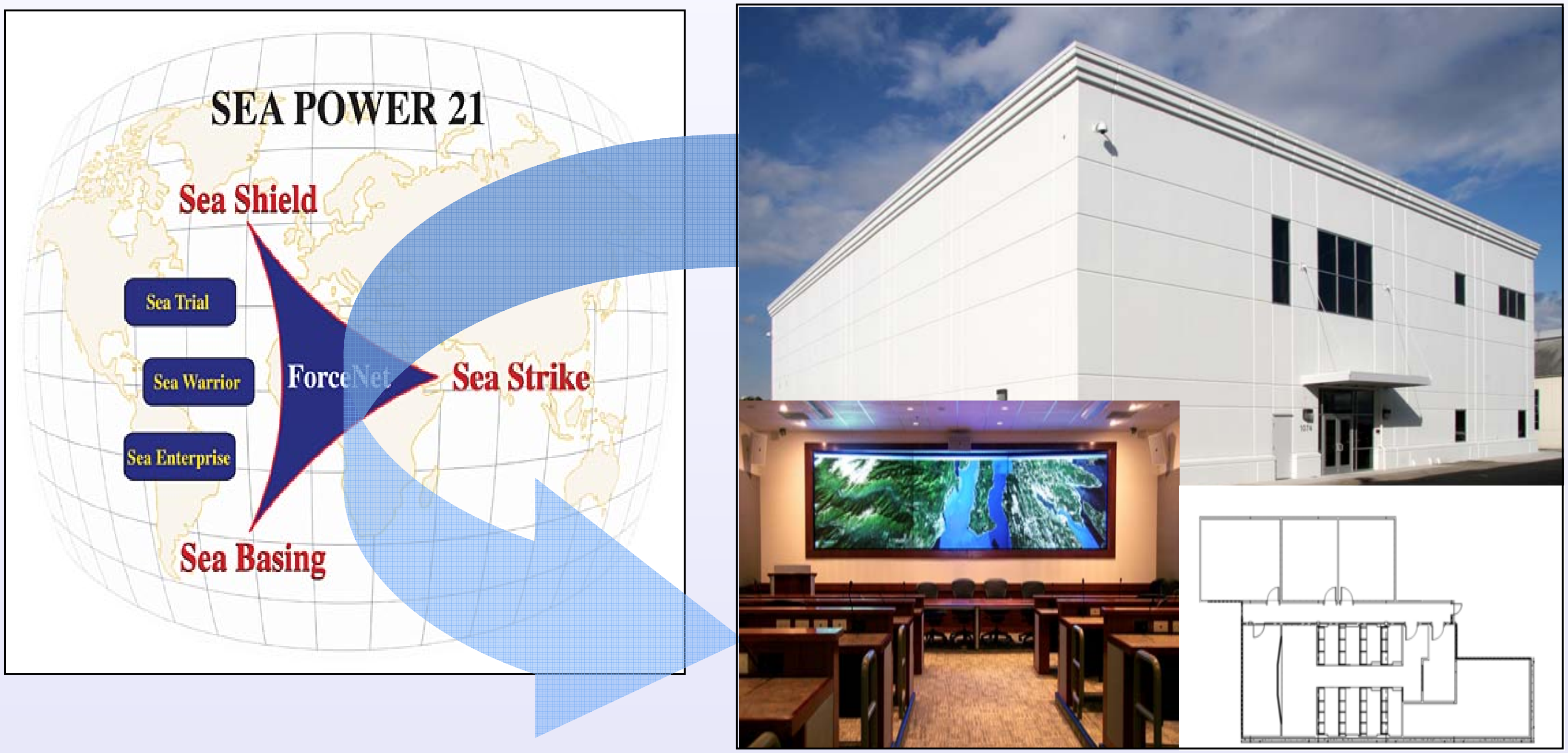
OUTLINE

- About NUWC Division Keyport
- About CTEC (Collaborative T&E Capability)
- ESMS (Event Streaming Media System):
  - What is it & Why?
  - Some Details about the ESMS tool
  - ESMS Replay
- Conclusion

About NUWC Division Keyport

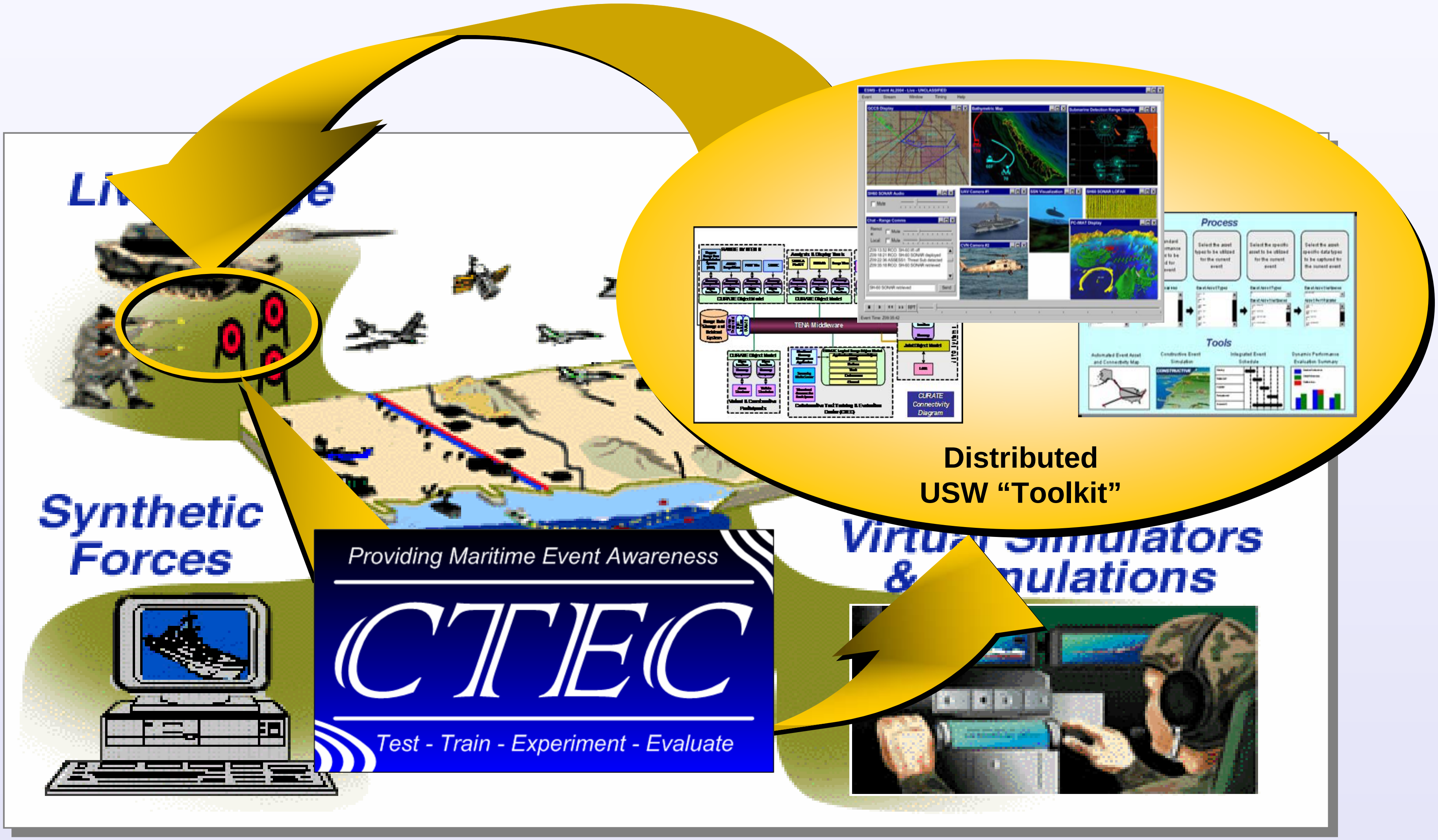


CTEC
(Collaborative Test & Evaluation Capability)



"… develop Sea Power 21 capabilities
… by coordinating war gaming, experimentation & exercises
… using technology push, concept pull, and spiral development
… with the Fleet at the heart of innovation."

CTEC
(Collaborative Test & Evaluation Capability)

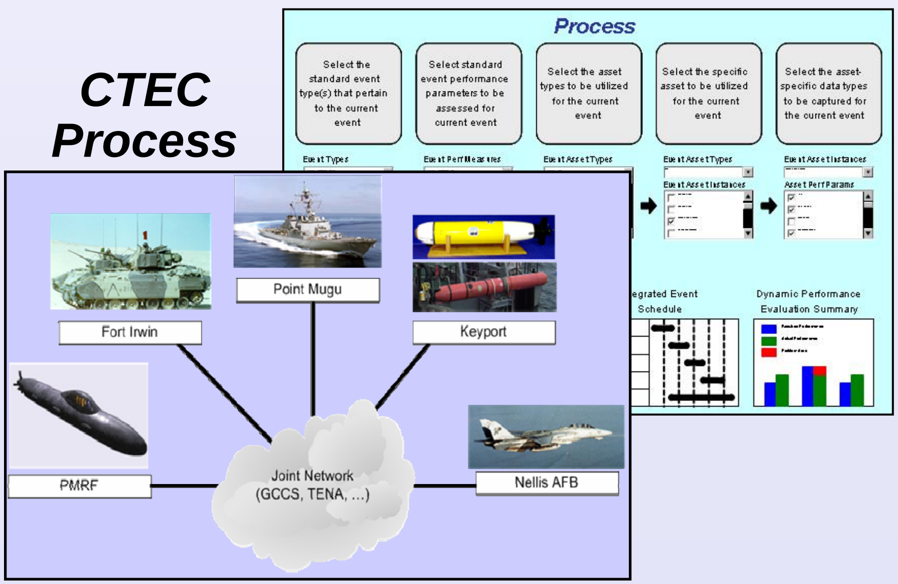


Focus Area: The Undersea / Littoral Warfare Component

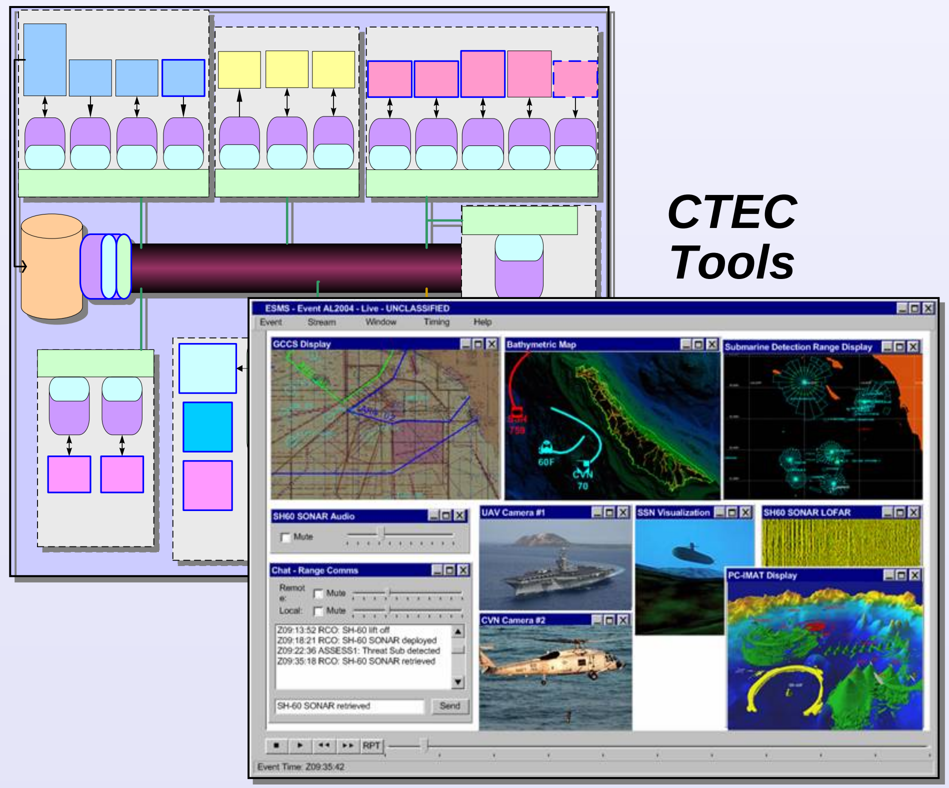
Strategy: CTEC Components

- CTEC, the ***Capability***, is comprised of three complementary components:
  - ***Facility***
  - ***Process***
  - ***Tools***

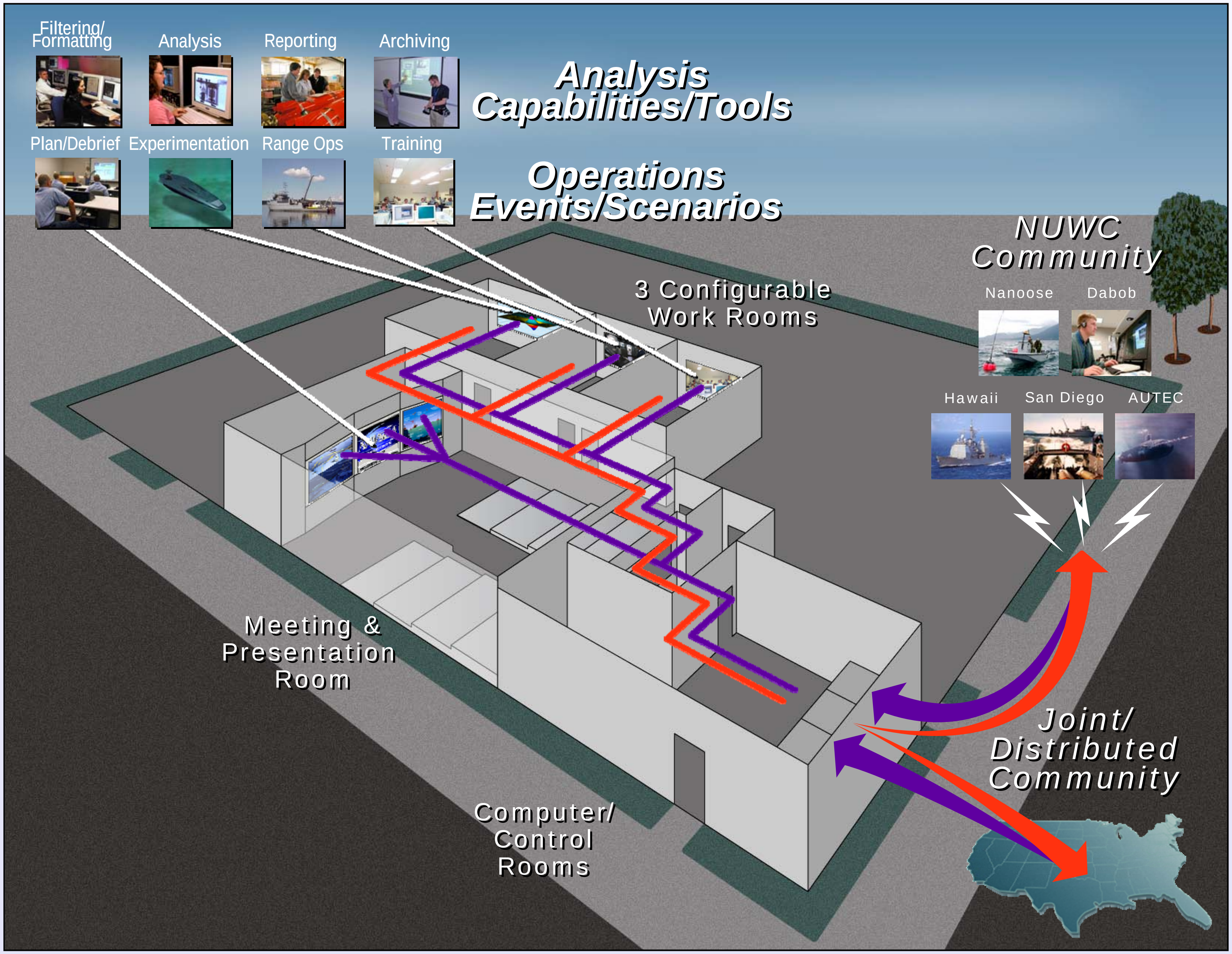
CTEC Process



CTEC Tools

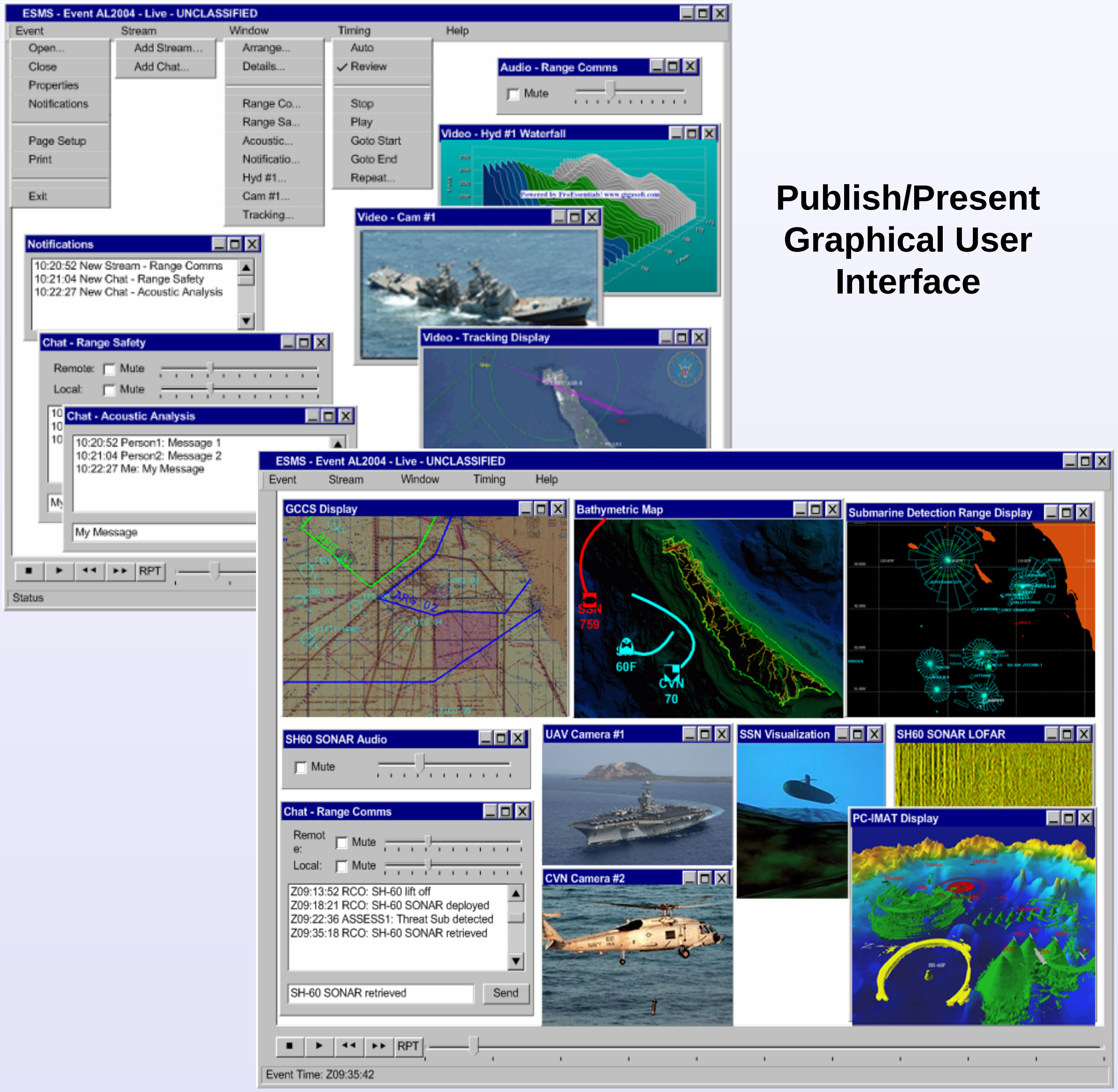


CTEC: Facility, Tools, & Process



NAVSEA WARFARE CENTERS KEYPORT

Event Streaming Media System (ESMS) Concept

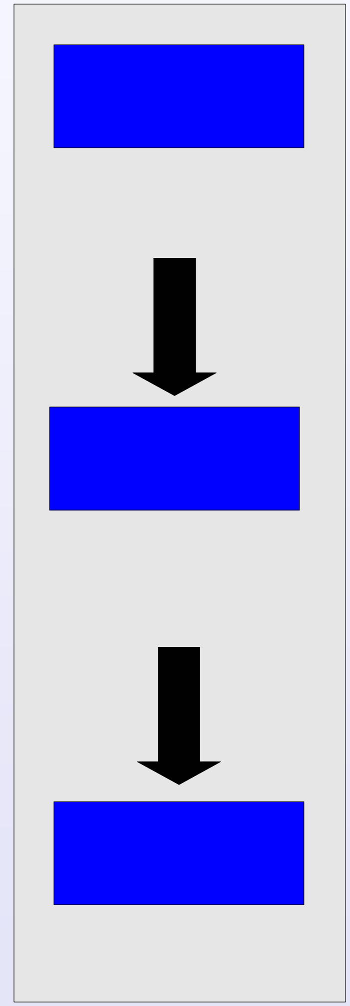


Publish/Present Graphical User Interface

Publish Client: IE w/Flash Player

Servers: Adobe Flash Comm Microsoft SQL

Presentat Client: IE w/Flash Player



Why ESMS Is Needed?

- **Limited event data correlation => limited insight**
- **Incomplete and/or inaccessible archive => limited cost effective test reconstruction**
- **Limited live event visibility => lower test productivity**
- **Diverse event viewing roles & requirements**
- **Extended duration events with ad hoc participation**
- **Complex event viewing & analysis applications**
- **Commercial media server products are not optimized for event insight**

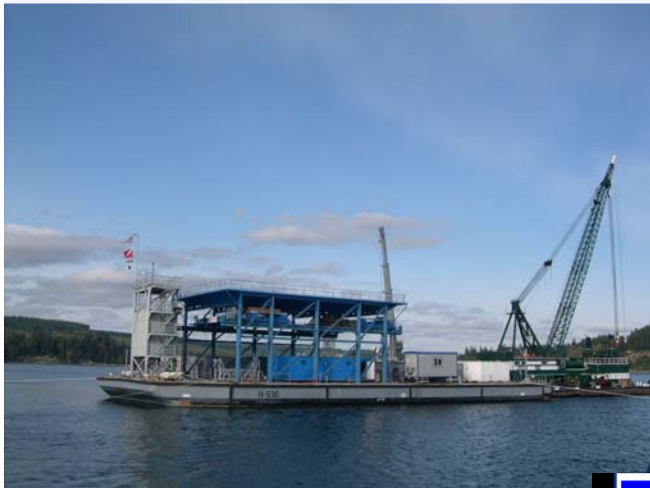
Performance Priorities

System Characteristic	Business Communication	Event Insight (ESMS)
Latency	1 (highest)	4 (lowest)
Bandwidth	2	3
Quality	3	2
Synchronization	4 (lowest)	1 (highest)

Desired Features

Feature Set	Total Features
Event Administration Management	6
Event Access Management	3
Stream Access Management	17
Stream Administration Management	2
Archived Stream Access Management	2
Offline Event Timing Management	5
Online Event Timing Management	2
Notification Management	3
Chat Access Management	7
User Administration Management	6
Group Administration Management	3
Event Archive Management	2
Presentation Formatting	2
NUWC Range Integration	1
Hardcopy Management	1
Help Management	2
Total	57

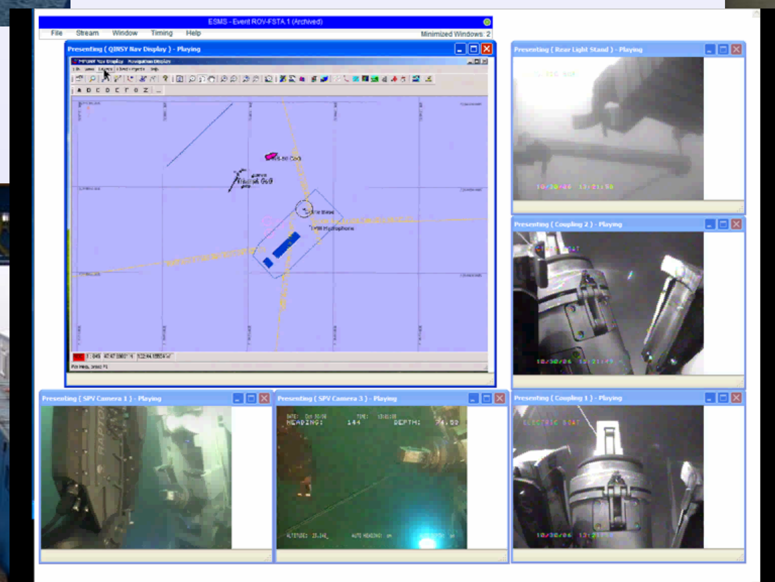
ESMS Event Replay



ESMS Display

Keyport Test Barge

Keyport Recovery Vehicle



ESMS - Event ROV-FSTA 1 (Archived)
File
Stream
Window
Timing
Help
Minimized Windows: 2
Presenting (QINSY Nav Display) - Playing
Presenting (Rear Light Stand) - Playing
Presenting (Coupling 2) - Playing
Presenting (SPV Camera 1) - Playing
Presenting (SPV Camera 3) - Playing
Presenting (Coupling 1) - Playing
HEADING:
DEPTH:
ELECTRIC BOAT

ESMS Event Replay

Summary

ESMS Features

- **Synchronous information** from distributed information sources (audio, video, screen capture) for a single event
- **Correlated analysis insight** in a distributed environment
- **Replay/review capability** ("TIVO" like)
- **Configurable perspectives** supporting insight for many job functions
- **Distributed collaboration** environment
- **Event comparison** through live archive access query
- **Continuous event life cycle** through re-publication
- **Distributed server design** to enhance communication performance

ESMS Fly-Away Kit

- *Panasonic Rugged notebooks*
- *PTZ Video Cameras*
- *Lorex Infrared Cameras*
- *Epiphan Frame Grabber*
- *Osprey 440 Video Capture Card*
- *A/V Cables*
- *Linksys Wireless Router & Hub*
- *Harris Wireless Bridge for SECNET-11*
- *Adobe Flash Media Server 2*
- *UPS Battery Backup*

Approved for public release
Distribution is unlimited
NUWC Public Affairs Office

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The Critical Link Between Test & Evaluation and Modeling & Simulation

Dr. Mark J. Kiemele
Air Academy Associates

A Tutorial for NDIA's
23rd Annual National Test and Evaluation Conference
Hilton Head Island, SC
March 12, 2007

Air Academy Associates
Simplify and Perfect

Introductions

- **Name**
- **Organization**
- **Job Title/Duties**
- **Experience in DOE, T&E, M&S**

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Agenda

- Some Basic Definitions
- Test and Evaluation (Experimental) Approaches
- DOE: the Gateway to Transfer Functions and Optimization
- Break
- Monte Carlo Simulation, Robust Design, and Tolerance Allocation
- Examples of Iterative Use of Modeling and Simulation
- Summary of “Modeling the Simulator”

Simplify and Perfect

Some Basic Definitions

- **System:** a collection of entities which act and interact together to achieve some goal
- **Model:** a simplified representation of a system developed for the purpose of studying a system
- **Simulation:** the manipulation of a model in such a way that it allows the investigation of the performance of a system
- **Modeling and Simulation:** a discipline for developing a level of understanding of the interaction of the parts of a system, and of the system as a whole

Simplify and Perfect

About Models

All models are simplifications of reality.

There is always a tradeoff as to what level of detail should be included in the model:

<u>If too little detail</u>, there is a risk of missing relevant interactions and the resultant model does not promote understanding.

<u>If too much detail</u>, there is a risk of overly complicating the model and actually preclude the development of understanding.

The "goodness" of a model depends on the extent to which it promotes understanding.

Simplify and Perfect

Types of Models

High-Fidelity Models:

- many variables and many interactions
- highly detailed and complex
- needed for visualization
- difficult to manipulate

Low-Fidelity Models:

- much fewer number of variables
- can be manipulated more easily
- provides higher-level view of system
- presents a more aggregate view of the system

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Types of Simulation

Deterministic Simulation:

- for each combination of inputs parameters, there is one and only one output value
- y = f(x)

Monte Carlo Simulation:

- provides for variability in the inputs
- y = f(x + variation), where the variation is modeled as some probability distribution

Discrete Event Simulation:

- studies a sequence of countable events
- assumption is that nothing of importance takes place between events

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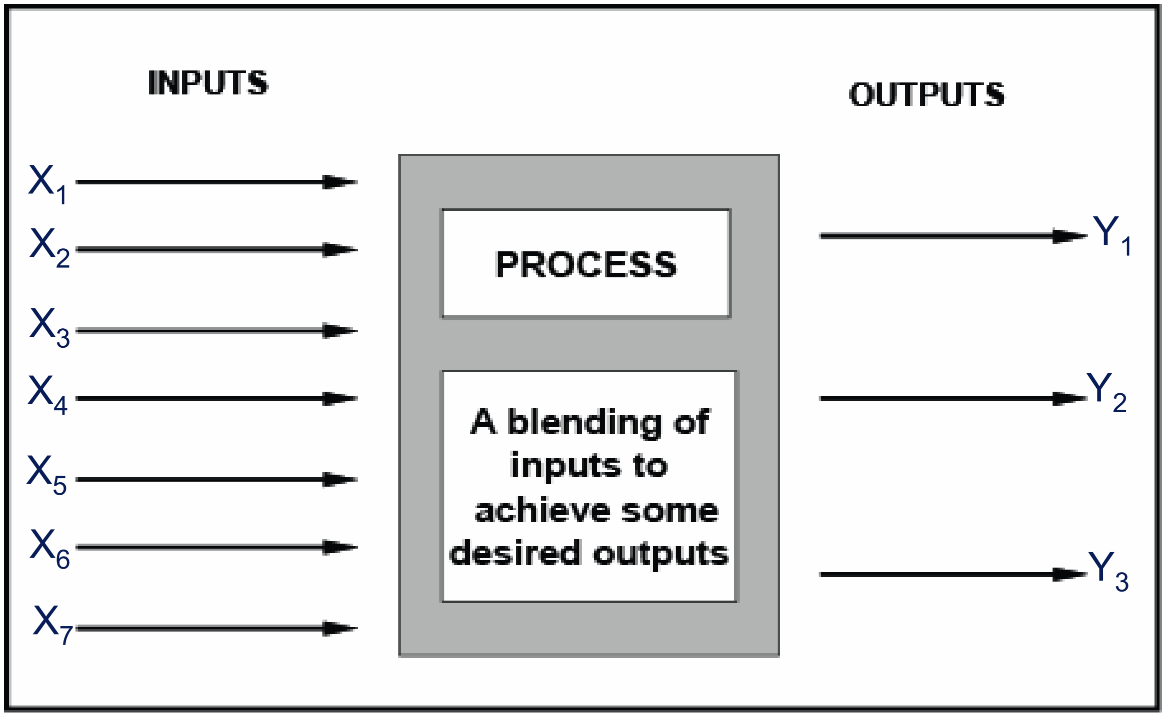
Definition of a Process



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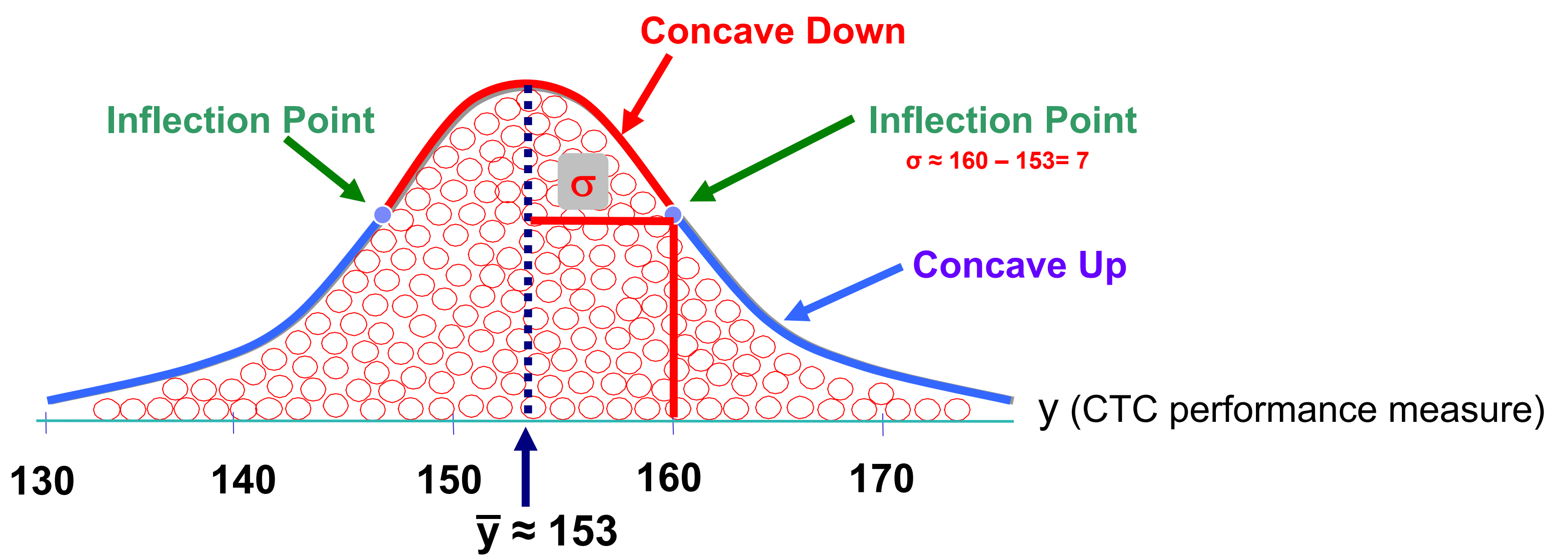
Graphical Meaning of $\bar{y}$ and σ

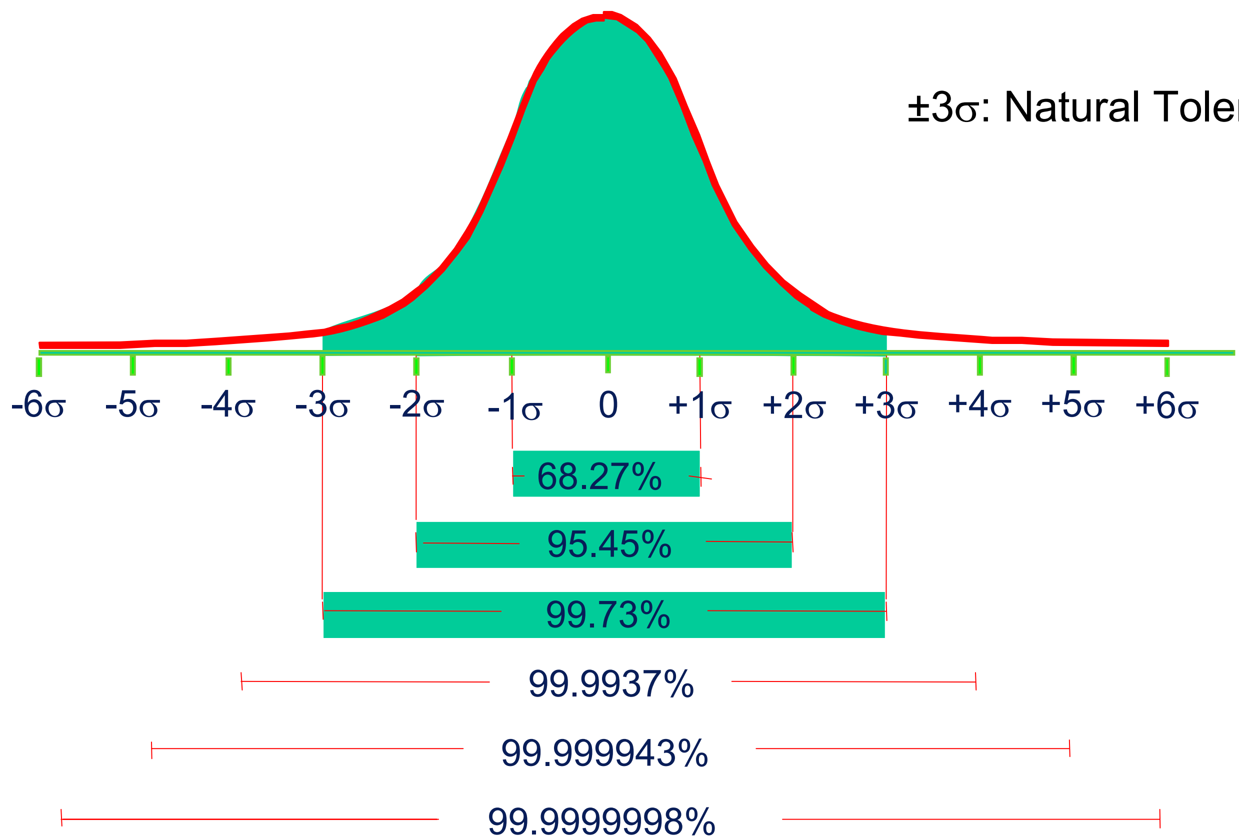
$\bar{y}$ = Average = Mean = Balance Point

σ = Standard Deviation



$\sigma \approx$ average distance of points from the centerline

Graphical View of Variation



Typical Areas under the Normal Curve

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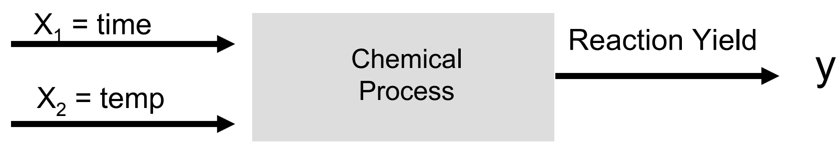
Experimental Methods

- **Traditional Approaches**
  - One Factor at a Time (OFAT)
  - Oracle (Best Guess)
  - All possible combinations (full factorial)

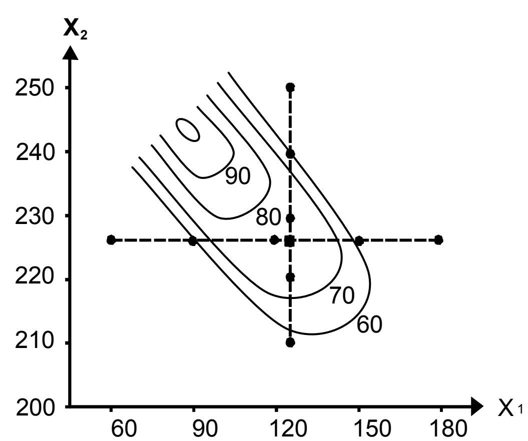
- **Modern Approach**
  - Statistically designed experiments (DOE) … full factorial plus other selected DOE designs, depending on the situation

Simplify and Perfect

OFAT (One Factor at a Time)



One factor at a time results versus optimal results



Oracle (Best Guess)

Run	W	P	E	C	A	Y
1	1	2	1	1	1	5
2	1	1	1	1	1	6
3	2	2	1	1	1	5
4	2	1	1	1	2	6
5	1	2	2	2	2	7
6	1	1	2	2	2	8
7	2	2	2	2	2	10
8	2	1	2	2	1	11

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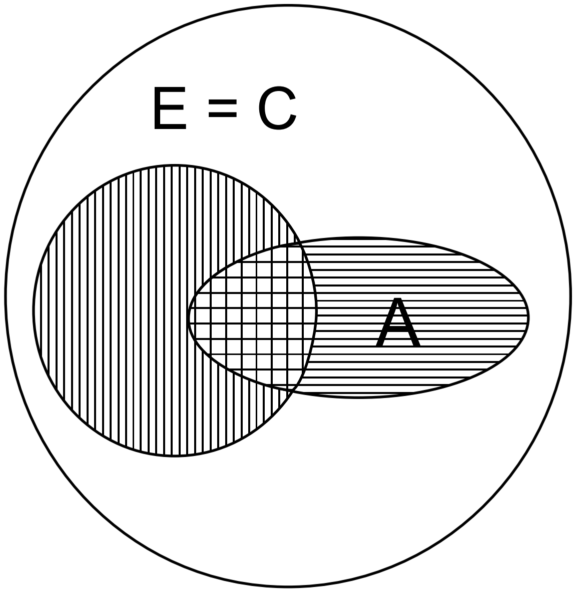
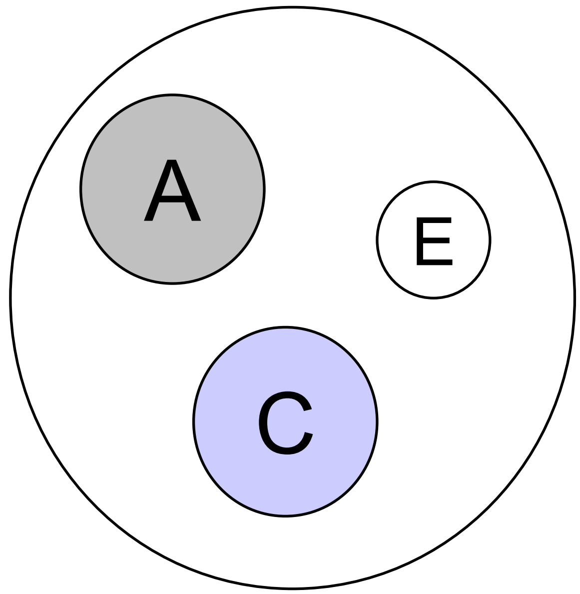
Evaluating the Effects of Variables on Y

What we have is:



What we need is a design to provide independent estimates of effects:



How do we obtain this independence of variables?

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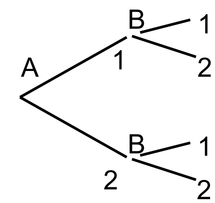
All Possible Combinations (Full Factorial)

MATRIX FORM | **TREE DIAGRAM**

Example 1:

A (2 levels)
B (2 levels)

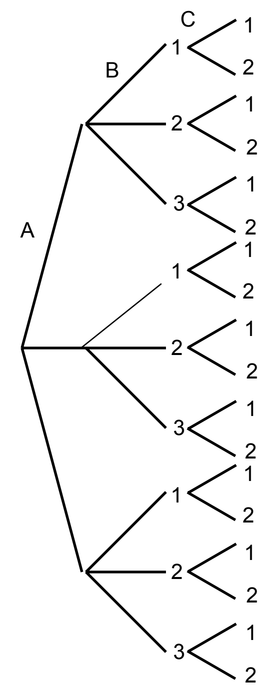
A	B
1	1
1	2
2	1
2	2



Example 2:

A (3 levels)
B (3 levels)
C (2 levels)

A	B	C
1	1	1
1	2	1
1	3	1
2	1	1
2	2	1
2	3	1
3	1	1
3	2	1
3	3	1
1	1	2
1	2	2
1	3	2
2	1	2
2	2	2
2	3	2
3	1	2
3	2	2
3	3	2



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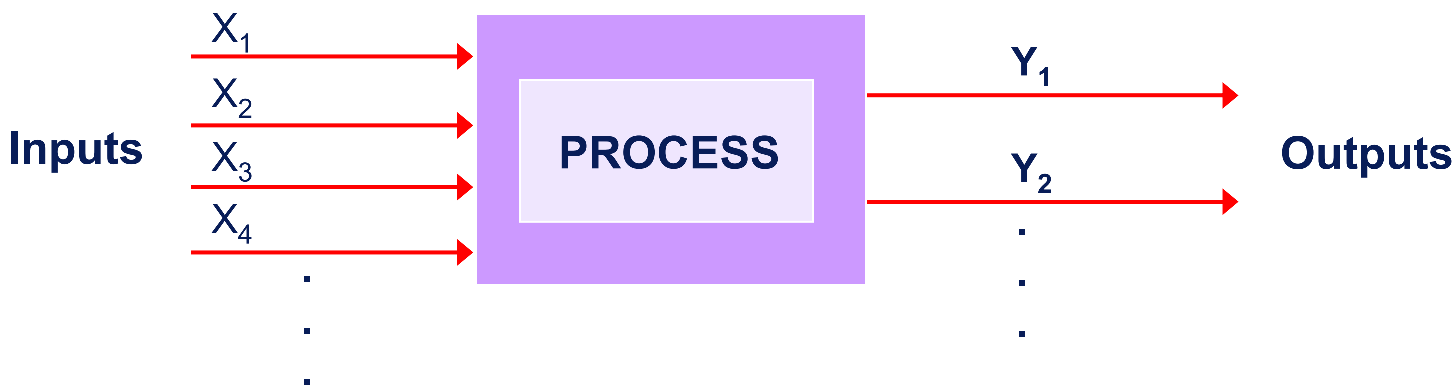
What Is a Designed Experiment?

Purposeful changes of the inputs (factors) in order to observe corresponding changes in the output (response).



Run	X_1	X_2	X_3	X_4	Y_1	Y_2	. . . . . .	$\bar{Y}$	S_Y
1									
2									
3									
.									
.									

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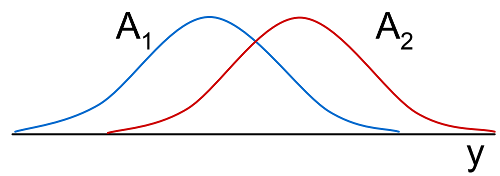
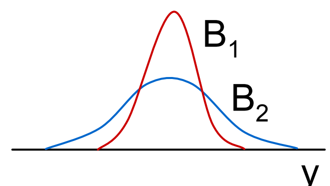
DOE Helps Determine How Inputs Affect Outputs

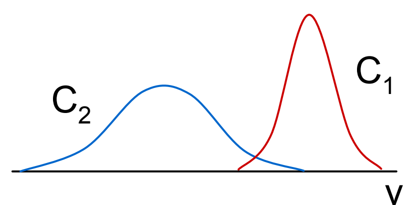
i) Factor A affects the average of y



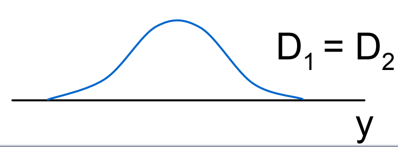
ii) Factor B affects the standard deviation of y



iii) Factor C affects the average and the standard deviation of y



iv) Factor D has no effect on y



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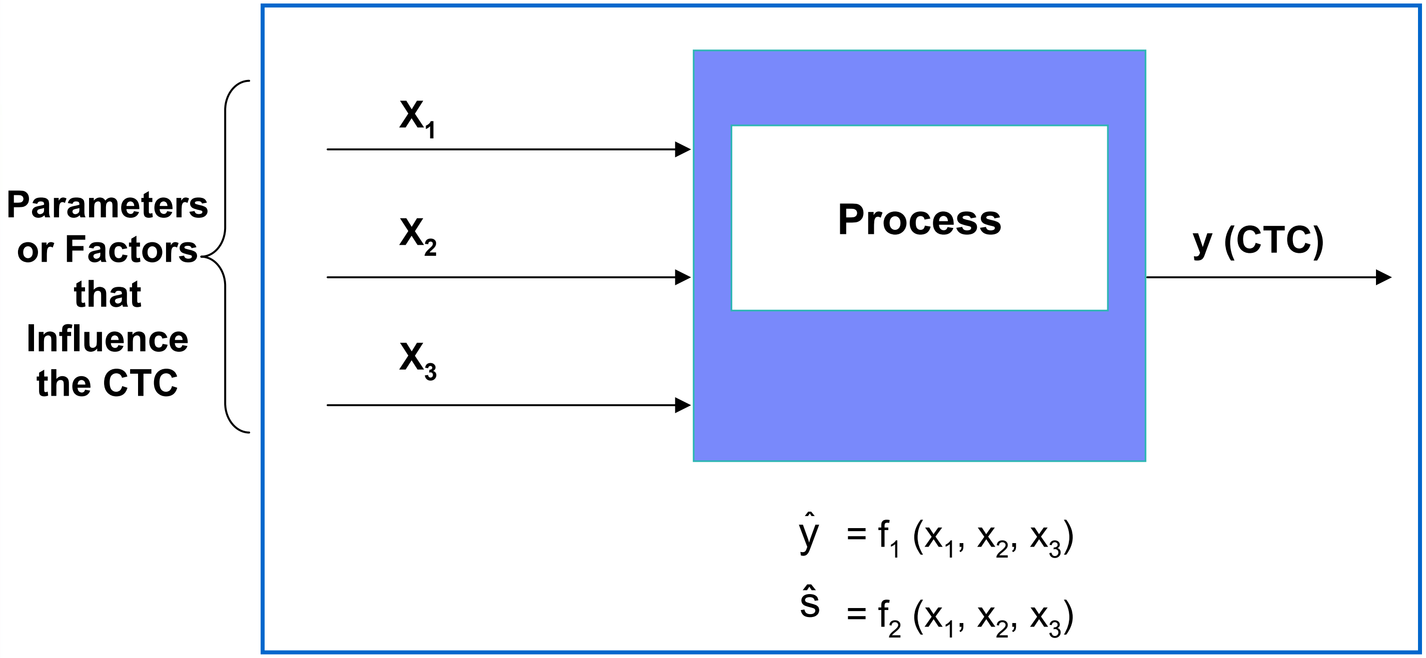
Transfer Functions

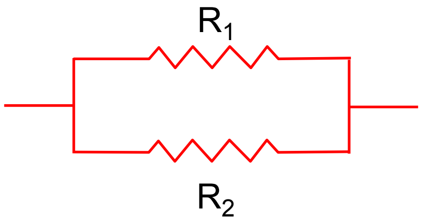


Where does the transfer function come from?

- **Exact transfer Function**
- **Approximations**
  - **DOE**
  - **Historical Data Analysis**
  - **Simulation**

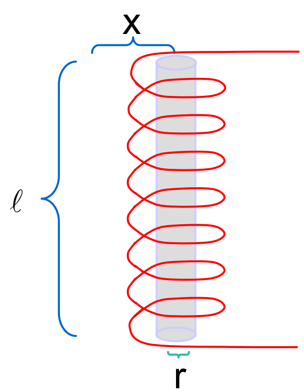
Exact Transfer Function

- Engineering Relationships
  - $V = IR$
  - $F = ma$



The equation for the impedance (Z) through this circuit is defined by:

$$Z = \frac{R_1 \cdot R_2}{R_1 + R_2}$$



The equation for magnetic force at a distance X from the center of a solenoid is:

$$H = \frac{NI}{2\ell}\left[\frac{.5\ell + x}{\sqrt{r^2 + (.5\ell + x)^2}} + \frac{.5\ell - x}{\sqrt{r^2 + (.5\ell - x)^2}}\right]$$

Where

- N : total number of turns of wire in the solenoid
- I : current in the wire, in amperes
- r : radius of helix (solenoid), in cm
- ℓ : length of the helix (solenoid), in cm
- x : distance from center of helix (solenoid), in cm
- H : magnetizing force, in amperes per centimeter

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Catapulting Power into Design of Experiments

Statapult ® Catapult

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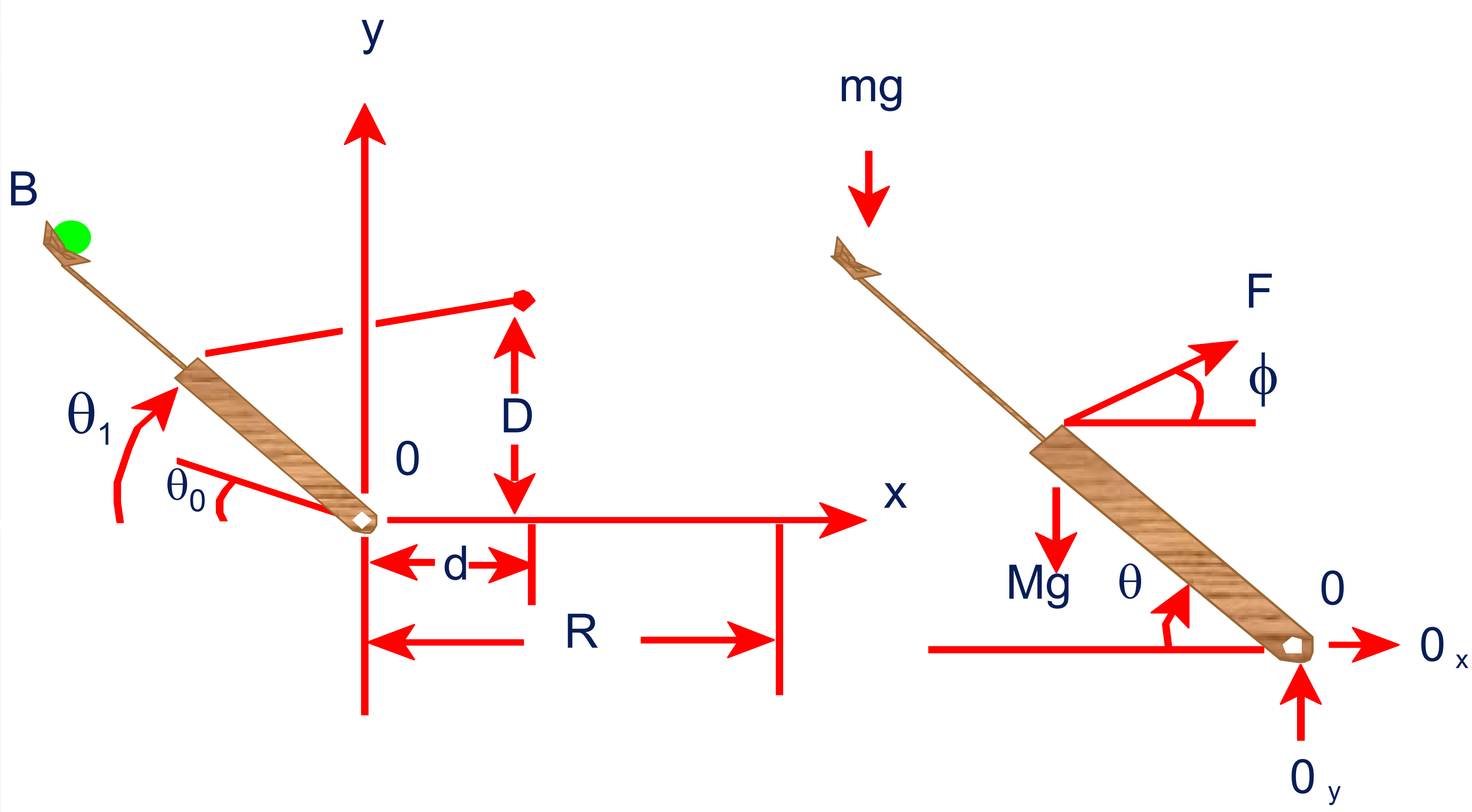
The Theoretical Approach



The Theoretical Approach (cont.)

$$I_0\ddot{\theta} = r_F F(\theta)\sin\theta\cos\varphi - (Mgr_G + mgr_B)\sin\theta \qquad \tan\phi = \frac{D - r_F\sin\theta}{d + r_F\cos\theta},$$

$$\frac{1}{2}I_0\dot{\theta}^2 = r_F\int_{\theta_0}^{\theta} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta - \sin\theta_0)$$

$$\frac{1}{2}I_0\dot{\theta}_1^2 = r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\varphi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

$$x = v_B\cos\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}r_B\cos\theta_1 \qquad y = r_B\sin\theta_1 + v_B\sin\left(\frac{\pi}{2} - \theta_1\right)t - \frac{1}{2}gt^2.$$

$$r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right) - \frac{g}{2V_B^2}\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)} = 0.$$

$$\frac{gI_0}{4r_B}\frac{(R + r_B\cos\theta_1)^2}{\cos^2\left(\frac{\pi}{2} - \theta_1\right)\left[r_B\sin\theta_1 + (R + r_B\cos\theta_1)\tan\left(\frac{\pi}{2} - \theta_1\right)\right]}$$

$$= r_F\int_{\theta_0}^{\theta_1} F(\theta)\sin\theta\cos\phi\, d\theta - (Mgr_G + mgr_B)(\sin\theta_1 - \sin\theta_0).$$

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Statapult® DOE Demo
(The Empirical Approach)

	Actual Factors		Coded Factors			Response Values			
Run	A	B	A	B	AB	Y_1	Y_2	$\bar{Y}$	S
1	144	2	-1	-1	+1				
2	144	3	-1	+1	-1				
3	160	2	+1	-1	-1				
4	160	3	+1	+1	+1				
		Avg –							
		Avg +							
		Δ							

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The Beauty of Orthogonality

A Full Factorial Design for 3 Factors A, B, and C, Each at 2 levels:

Run	**A**	**B**	**C**	AB	AC	BC	ABC
1	-	-	-	+	+	+	-
2	-	-	+	+	-	-	+
3	-	+	-	-	+	-	+
4	-	+	+	-	-	+	-
5	+	-	-	-	-	+	+
6	+	-	+	-	+	-	-
7	+	+	-	+	-	-	-
8	+	+	+	+	+	+	+

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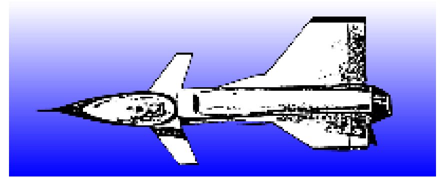
Value Delivery: Reducing Time to Market for New Technologies



INPUT

Pitch <) (0, 15, 30)

Roll <) (0, 15, 30)

W1F <) (-15, 0, 15)

W2F <) (-15, 0, 15)

W3F <) (-15, 0, 15)

Modeling Flight Characteristics of New 3-Wing Aircraft

OUTPUT

Six Aero-Characteristics

- **Total # of Combinations = 3^5 = 243**
- **Central Composite Design: n = 30**

Patent Holder: Dr. Bert Silich

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Aircraft Equations

$$C_L = .233 + .008(P)^2 + .255(P) + .012(R) - .043(WD1) - .117(WD2) + .185(WD3) + .010(P)(WD3) - .042(R)(WD1) + .035(R)(WD2) + .016(R)(WD3) + .010(P)(R) - .003(WD1)(WD2) - .006(WD1)(WD3)$$

$$C_D = .058 + .016(P)^2 + .028(P) - .004(WD1) - .013(WD2) + .013(WD3) + .002(P)(R) - .004(P)(WD1) - .009(P)(WD2) + .016(P)(WD3) - .004(R)(WD1) + .003(R)(WD2) + .020(WD1)^2 + .017(WD2)^2 + .021(WD3)^2$$

$$C_Y = -.006(P) - .006(R) + .169(WD1) - .121(WD2) - .063(WD3) - .004(P)(R) + .008(P)(WD1) - .006(P)(WD2) - .008(P)(WD3) - .012(R)(WD1) - .029(R)(WD2) + .048(R)(WD3) - .008(WD1)^2$$

$$C_M = .023 - .008(P)^2 + .004(P) - .007(R) + .024(WD1) + .066(WD2) - .099(WD3) - .006(P)(R) + .002(P)(WD2) - .005(P)(WD3) + .023(R)(WD1) - .019(R)(WD2) - .007(R)(WD3) + .007(WD1)^2 - .008(WD2)^2 + .002(WD1)(WD2) + .002(WD1)(WD3)$$

$$C_{YM} = .001(P) + .001(R) - .050(WD1) + .029(WD2) + .012(WD3) + .001(P)(R) - .005(P)(WD1) - .004(P)(WD2) - .004(P)(WD3) + .003(R)(WD1) + .008(R)(WD2) - .013(R)(WD3) + .004(WD1)^2 + .003(WD2)^2 - .005(WD3)^2$$

$$C_e = .003(P) + .035(WD1) + .048(WD2) + .051(WD3) - .003(R)(WD3) + .003(P)(R) - .005(P)(WD1) + .005(P)(WD2) + .006(P)(WD3) + .002(R)(WD1)$$

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Hierarchical Transfer Functions

$$Y = \text{Gross Margin} = \frac{\text{Gross Profit}}{\text{Gross Revenue}}$$

$$Y = f(y_1, y_2, y_3, y_4, y_5, y_6)$$

$$= \frac{(\underbrace{\text{Rev}_{\text{equip}}}_{y_1} - \underbrace{\text{COG}}_{y_2}) + (\underbrace{\text{Rev}_{\text{post sales}}}_{y_3} - \underbrace{\text{Cost}_{\text{post sales}}}_{y_4}) + (\underbrace{\text{Rev}_{\text{fin}}}_{y_5} - \underbrace{\text{Cost}_{\text{fin}}}_{y_6})}{y_1 + y_3 + y_5}$$

$$\underbrace{\text{Cost}_{\text{post sales}}}_{y_4} = f(\underbrace{\text{field cost}}_{x_1}, \underbrace{\text{remote services}}_{x_2}, \underbrace{\text{suppliers}}_{x_3})$$

$$x_1 = f(\text{direct labor, freight, parts, depreciation})$$

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Modeling The Drivers of Turnover

① External Market Factors (Local Labor Market Conditions)
- Local Unemployment Rate
- Local Employment Alternatives
- Company's Market Share

② Organizational Characteristics and Practices
- Supervisor Stability
- Lateral / Upward Mobility
- Layoff Climate

③ Employee Attributes
- Time Since Last Promotion
- Education Level
- Job Stability History

→ **Process of Deciding to Stay / Leave** → Turnover Rate

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DOE "Market Research" Example

Suppose that, in the auto industry, we would like to investigate the following automobile attributes (i.e., factors), along with accompanying levels of those attributes:

A: Brand of Auto:	**-1 = foreign**		**+1 = domestic**
B: Auto Color:	**-1 = light**	**0 = bright**	**+1 = dark**
C: Body Style:	**-1 = 2-door**	**0 = 4-door**	**+1 = sliding door/hatchback**
D: Drive Mechanism:	**-1 = rear wheel**	**0 = front wheel**	**+1 = 4-wheel**
E: Engine Size:	**-1 = 4-cylinder**	**0 = 6-cylinder**	**+1 = 8-cylinder**
F: Interior Size:	**-1 ≤ 2 people**	**0 = 3-5 people**	**+1 ≥ 6 people**
G: Gas Mileage:	**-1 ≤ 20 mpg**	**0 = 20-30 mpg**	**+1 ≥ 30 mpg**
H: Price:	**-1 ≤ $20K**	**0 = $20-$40K**	**+1 ≥ $40K**

In addition, suppose the respondents chosen to provide their preferences to product profiles are taken based on the following demographic:

J: Age:	**-1 ≤ 25 years old**	**+1 ≥ 35 years old**
K: Income:	**-1 ≤ $30K**	**+1 ≥ $40K**
L: Education:	**-1 < BS**	**+1 ≥ BS**

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DOE "Market Research" Example (cont.)

Question: Choose the best design for evaluating this scenario

Answer: L_{18} design with attributes A - H in the inner array and factors J, K, and L in the outer array, resembling an L_{18} robust design, as shown below:

									L	-	+	-	+	-	+	-	+		
									K	-	-	+	+	-	-	+	+		
									J	-	-	-	-	+	+	+	+		
Run*	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**		y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	$\bar{y}$	s
1	-	-	-	-	-	-	-	-											
2	-	-	0	0	0	0	0	0											
3	-	-	+	+	+	+	+	+											
4	-	0	-	-	0	0	+	+											
5	-	0	0	0	+	+	-	-											
6	-	0	+	+	-	-	0	0											
7	-	+	-	0	-	+	0	+											
8	-	+	0	+	0	-	+	-											
9	-	+	+	-	+	0	-	0											
10	+	-	-	+	+	0	0	-											
11	+	-	0	-	-	+	+	0											
12	+	-	+	0	0	-	-	+											
13	+	0	-	0	+	-	+	0											
14	+	0	0	+	-	0	-	+											
15	+	0	+	-	0	+	0	-											
16	+	+	-	+	0	+	-	0											
17	+	+	0	-	+	-	0	+											
18	+	+	+	0	-	0	+	-											

Segmentation of the population or

<u>Respondent Profiles</u>

* 18 different product profiles

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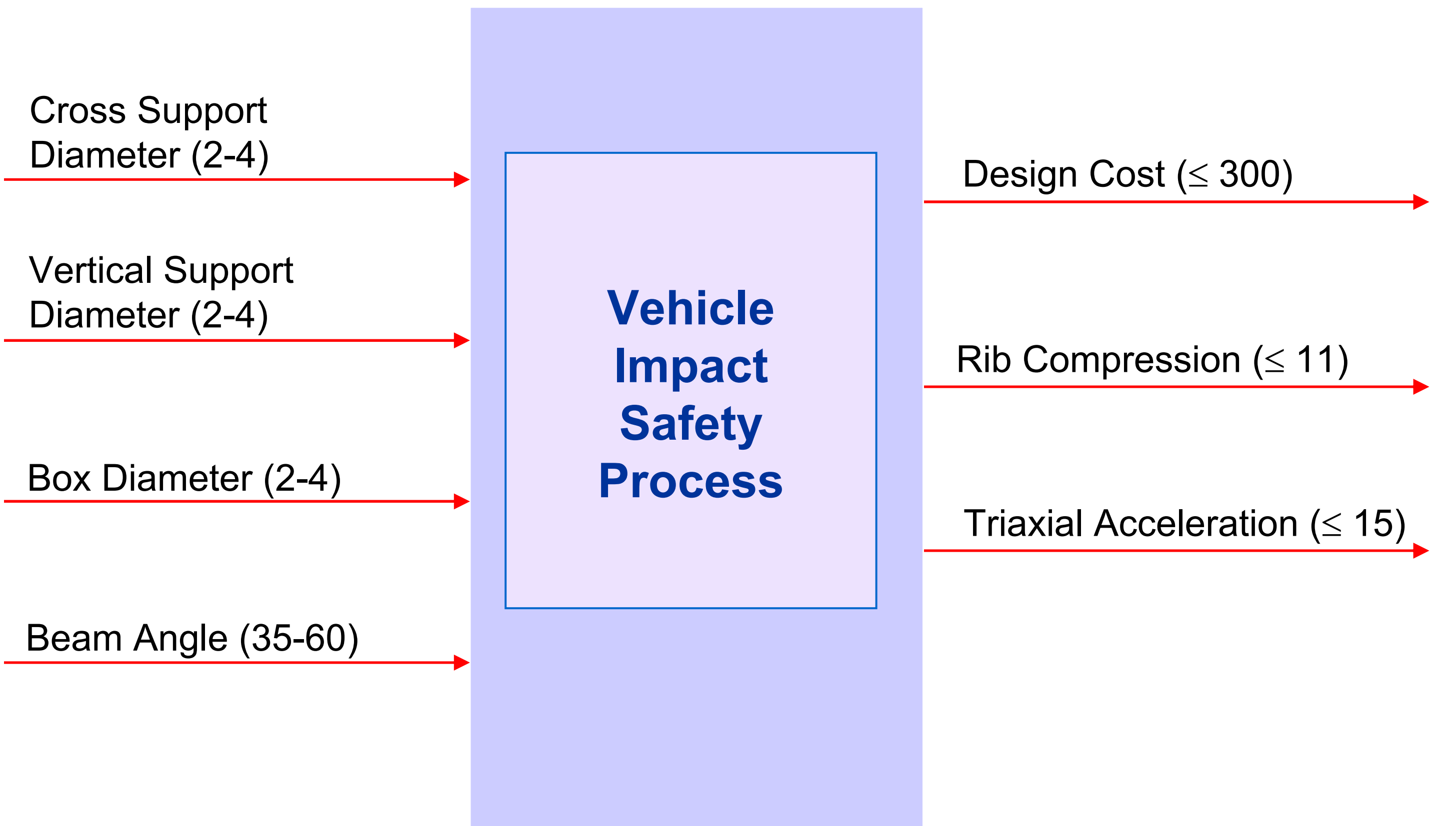
Multiple Response Optimization Simulation Example



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Optimization Using Monte Carlo Simulation

- **Expected Value Analysis**
- **Robust Design**
- **Tolerance Allocation**

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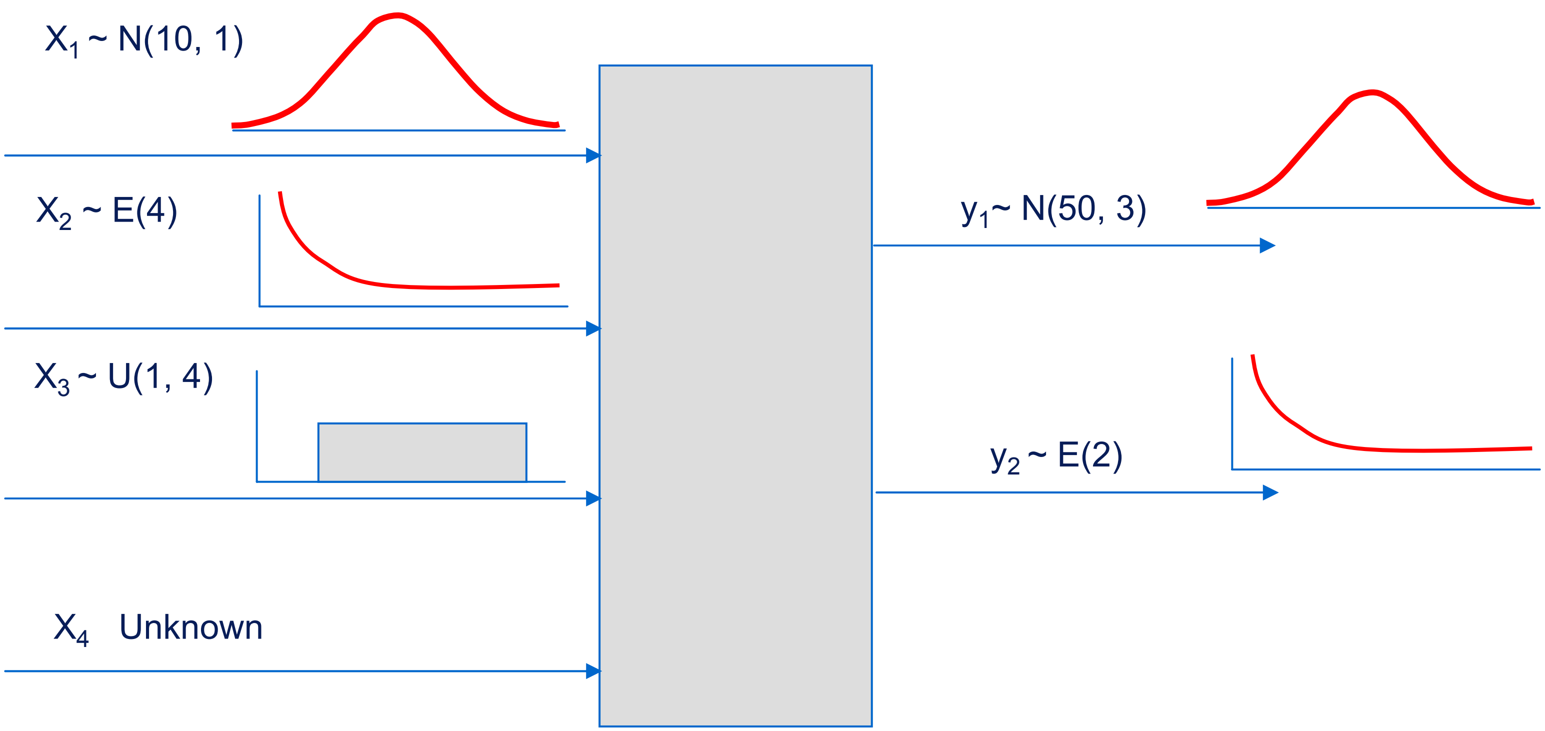
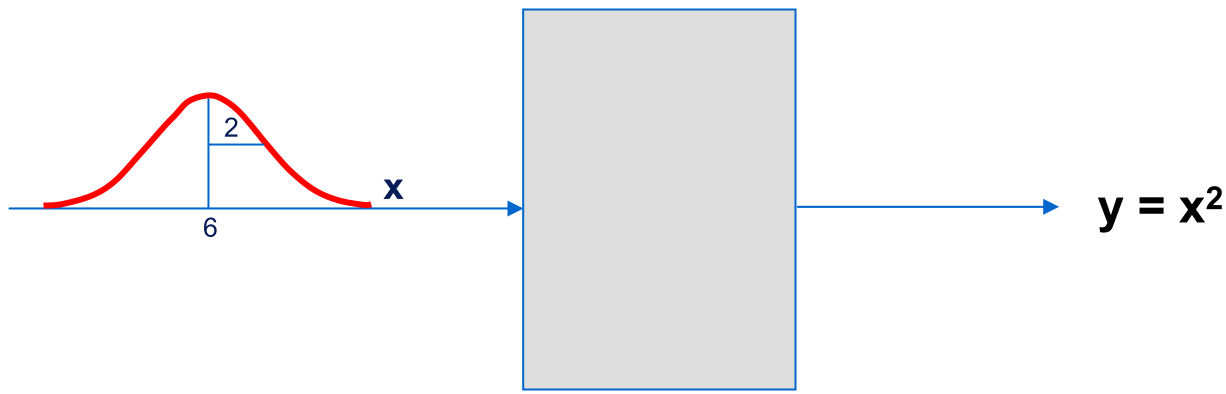
Expected Value Analysis (EVA)

Previously, we discussed variability in the outputs in great detail. However, the inputs also have variability.



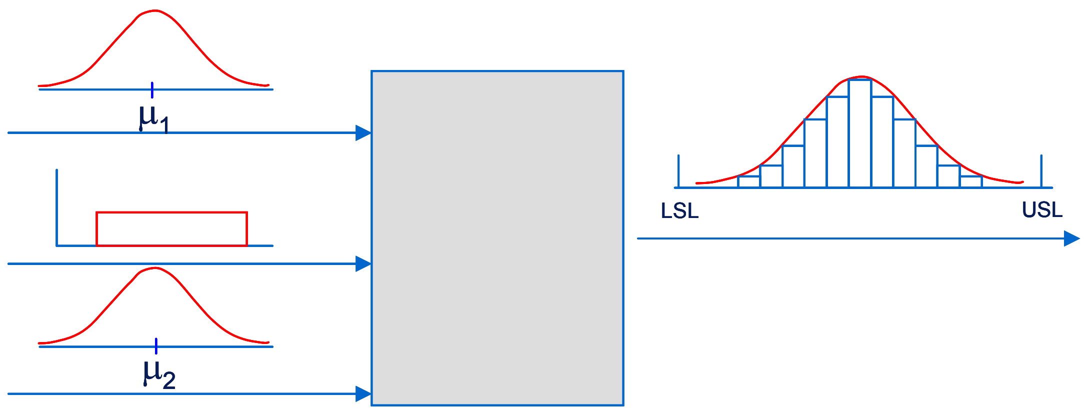
If a product has never been produced, how do we know what the distribution of the output is? What is the expected value and variance of y?

Expected Value Analysis Example

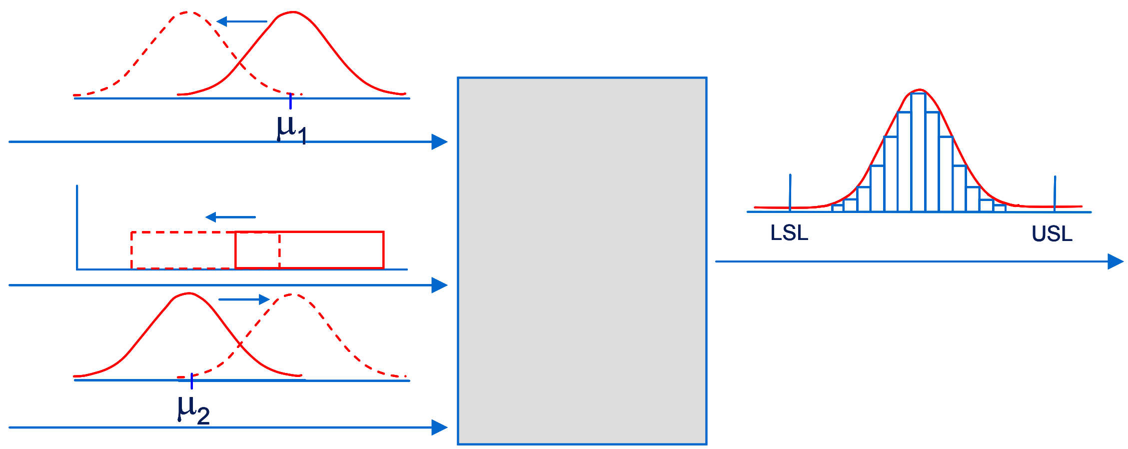


- **What is the shape of the output (y) distribution?**
- **What is the mean or expected value of the y distribution?**
- **What is the standard deviation of the y distribution?**

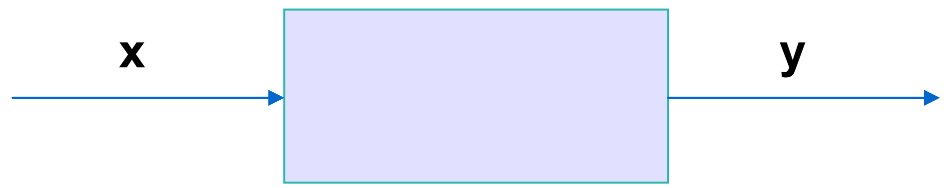
Robust Design



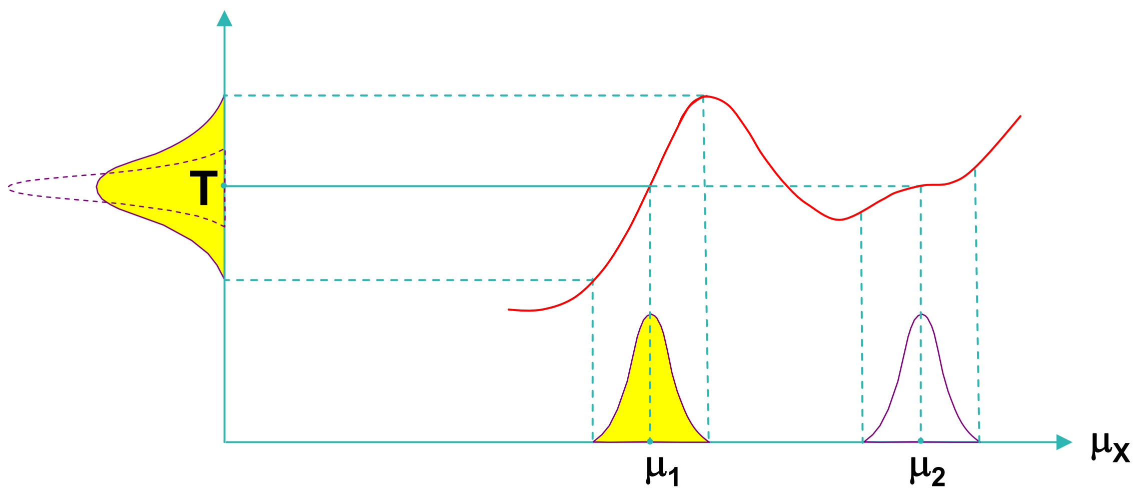
Process of finding the optimal location parameters (i.e., means) of the input variables to minimize dpm.



Why Robust Design?



One Input



If μ_X varies, should we select μ_1 or μ_2 to hit y = T?

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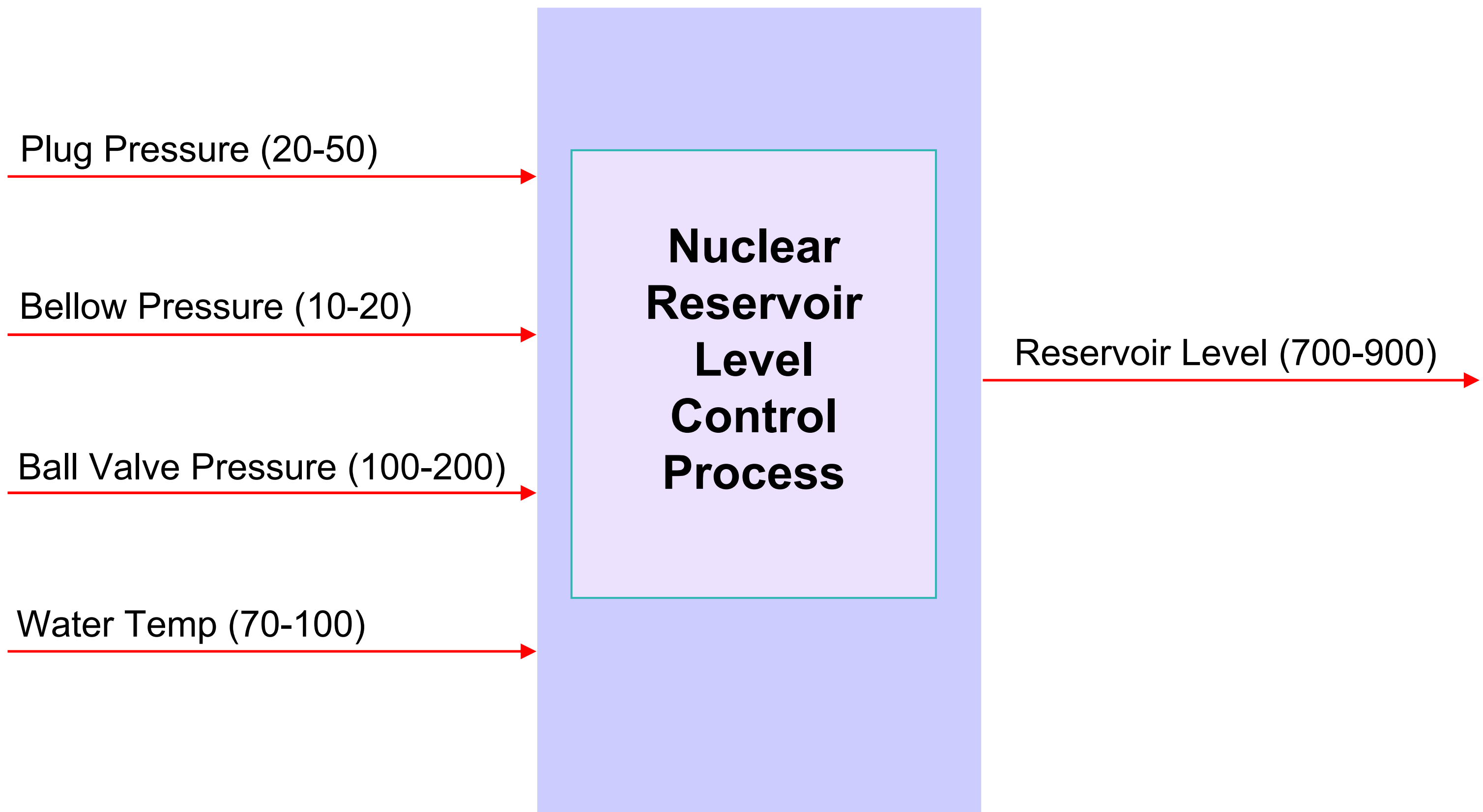
Robust (Parameter) Design Simulation Example



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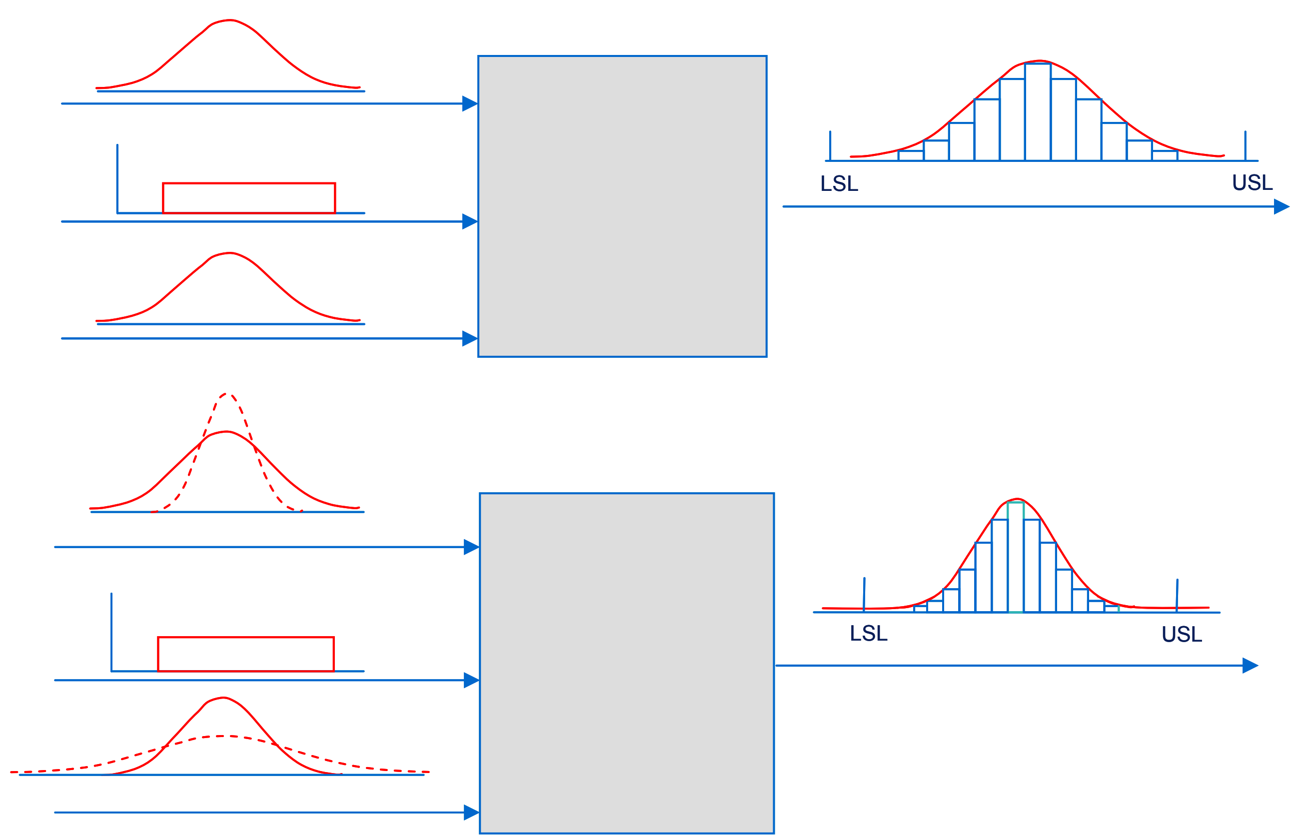
Tolerance Allocation (TA)



The process of quantifying the sensitivity of the output (y) dpm to changes in the input variables' (X's) standard deviations. It provides the designer the ability to perform cost/benefit tradeoffs via assignment of standard deviations to the input variables.

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Tolerance Allocation Example

$R_1 \sim N(50, 2^2)$

$R_2 \sim N(100, 2^2)$

Impedance Example

$$Z = \frac{R_1 \bullet R_2}{R_1 + R_2}$$

LSL = 31

USL = 35

If we were able to change a resistor's standard deviation, which resistor, R_1 or R_2, would have the greater impact on the dpm of Z (impedance)?

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Tolerance Allocation Example (cont.)

A reduction of R_1 by 50% reduces dpm by an order of magnitude X, while R_2 has little impact.

Tolerance Allocation Table N = 10,000 (in defects per million)		
Impedance Table		
	R1	**R2**
-50% Sigma	372.40	34,683
-25% Sigma	8,058	36,849
-10% Sigma	23,906	35,663
Nominal	39,220	39,657
+10% Sigma	59,508	37,556
+25% Sigma	92,398	47,317
+50% Sigma	148,113	46,801

A reduction of R_1's standard deviation by 50% combined with an increase in R_2's standard deviation by 50%

$R_1 \sim N(50, 1^2)$

$R_2 \sim N(100, 3^2)$

results in a dpm = 1,254.

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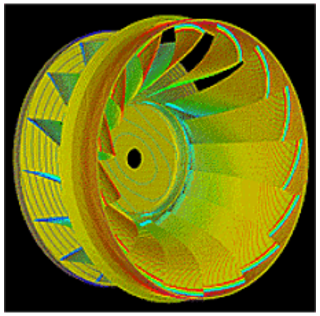
Examples of Simulation and High Performance Computing (HPC)

Power

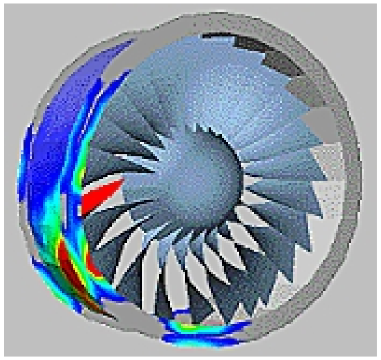


Simulation of stress and vibrations of turbine assembly for use in nuclear power generation

Automotive

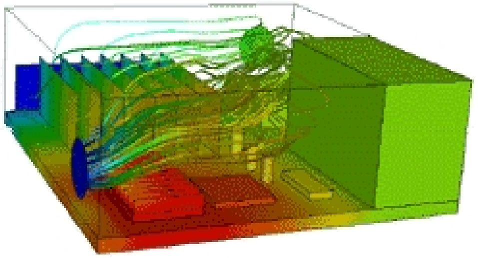
Simulation of underhood thermal cooling for decrease in engine space and increase in cabin space and comfort

Aerospace



Evaluation of dual bird-strike on aircraft engine nacelle for turbine blade containment studies

Electronics



Evaluation of cooling air flow behavior inside a computer system chassis

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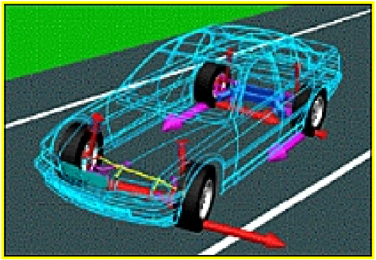
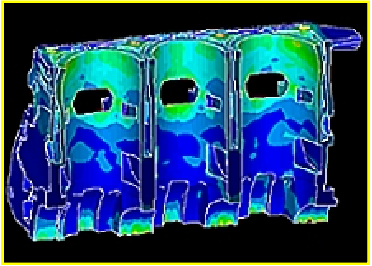
Examples of Computer Aided Engineering (CAE) and Simulation Software



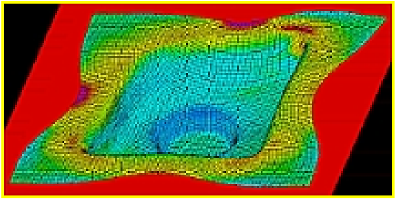
Mechanical motion: **Multibody kinetics and dynamics**

- ADAMS®
- DADS



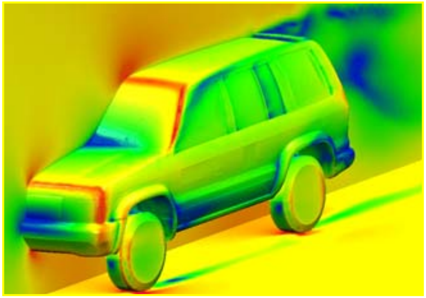
Implicit Finite Element Analysis: **Linear and nonlinear statics, dynamic response**

- MSC.Nastran™, MSC.Marc™
- ANSYS®
- Pro MECHANICA
- ABAQUS® Standard and Explicit
- ADINA



Explicit Finite Element Analysis : **Impact simulation, metal forming**

- LS-DYNA
- RADIOSS
- PAM-CRASH®, PAM-STAMP



General Computational Fluid Dynamics: **Internal and external flow simulation**

- STAR-CD
- CFX-4, CFX-5
- FLUENT®, FIDAP™
- PowerFLOW®

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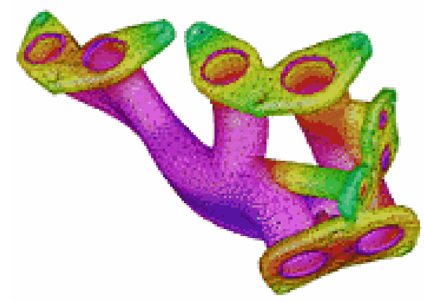
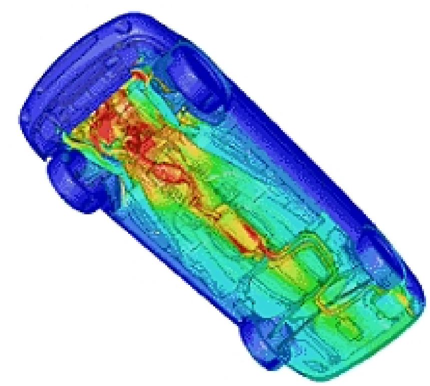
Examples of Computer Aided Engineering (CAE) and Simulation Software (cont.)

Preprocessing: Finite Element Analysis and Computational Fluid Dynamics mesh generation



- ICEM-CFD
- Gridgen
- Altair® HyperMesh®
- I-deas®
- MSC.Patran
- TrueGrid®
- GridPro
- FEMB
- ANSA

Postprocessing: Finite Element Analysis and Computational Fluid Dynamics results visualization



- Altair® HyperMesh®
- I-deas
- MSC.Patran
- FEMB
- EnSight
- FIELDVIEW
- ICEM CFD Visual3 2.0 (PVS)
- COVISE

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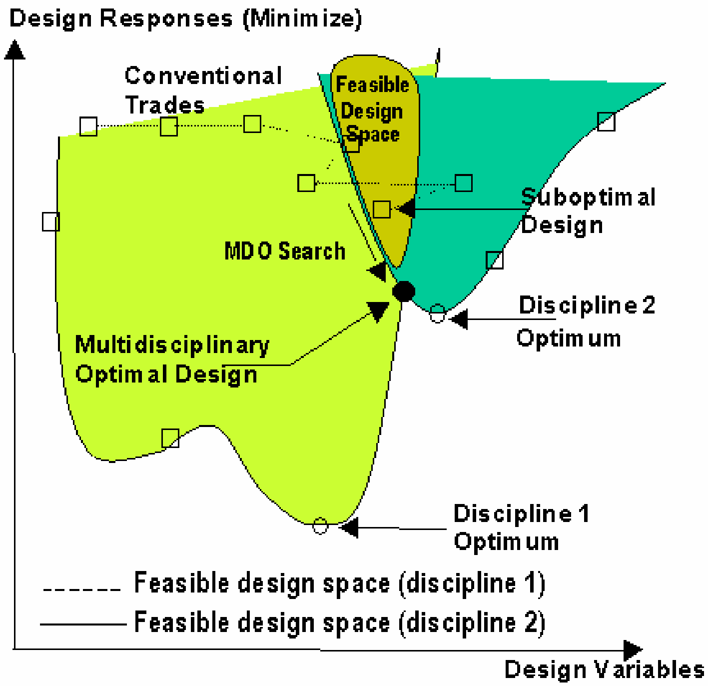
Multidisciplinary Design Optimization (MDO): A Design Process Application



- CFD
- Structures
- Performance
- Controls
- Cost

- NVH
- Safety
- Durability
- Controls Stability
- Cost

Key Elements of MDO

- Massive Computational Problem;
- Solution by decomposition effective for complex systems;
- Multiprocessor computing simplifies MDO solutions conceptually & enables solutions previously intractable;
- Aids in the management of the design process.

Mastery of interactions between the disciplines (or, subsystems) is as important as the methods & tools used within a single discipline

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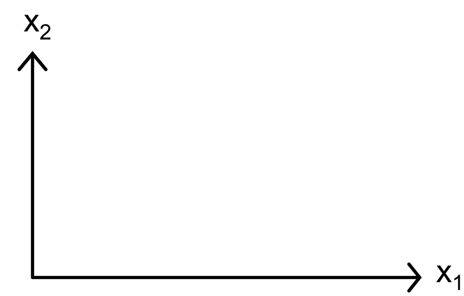
Latin Hypercube Sampling

- Method to populate the design space when using deterministic simulation models.



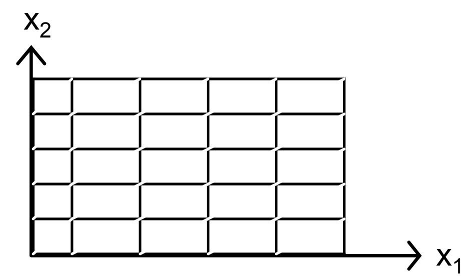
- Design space has k variables (or dimensions).

  Ex: Assume k = 2

- Suppose a sample of size n is to be taken; Stratify the design space into n^k cells.

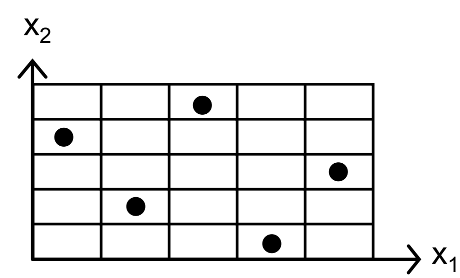
  Ex: Assume n = 5; $n^k = 5^2 = 25$

  Note: there are n strata for each of the k dimensions.



- Each of the n points is sampled such that each marginal strata is represented only once in the sample.

  Note: each sample point has its own unique row and column.



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Applying Modeling and Simulation to Automotive Vehicle Design

IDENTIFY CTCs, CDPs — Many, Many x's → **SCREENING DESIGN (DOE PRO)** — The critical few CDP's →

Examples of CTCs:

NASTRAN RADIOSS MADYMO

Integrated processes with high fidelity CAE analyses on HPC servers

Safety CTCs with constraints specified by FMVSS (Federal Motor Vehicle Safety Standards):

- y_1 = weight of vehicle
- y_2 = cost of vehicle
- y_3 = frontal head impact
- y_4 = frontal chest impact
- y_5 = toe board intrusion
- y_6 = hip deflection
- y_7 = rollover impact
- y_8 = side impact

(y_3–y_8: RADIOSS, DYNA, MADYMO)

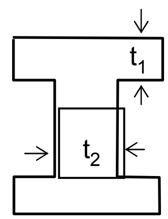
no federal requirements on these CTCs:

- y_9 = internal aerodynamics (airflow)
- y_{10} = external aerodynamics (airflow)
- y_{11} = noise
- y_{12} = vibration (e.g., steering wheel)
- y_{13} = harshness (e.g., over bumps, shocks)
- y_{14} = durability (at 100K miles)

(y_9–y_{10}: CFD; y_{11}–y_{14}: NASTRAN)

Examples of Critical Design Parameters (CDPs or Xs):

- x_1 = roof panel material
- x_2 = roof panel thickness
- x_3 = door pillar dimensions $\Rightarrow$ i beam
- x_4 = shape/geometry
- x_5 = windshield glass
- x_6 = hood material, sizing and thickness
- x_7 = under hood panel material, sizing and thickness



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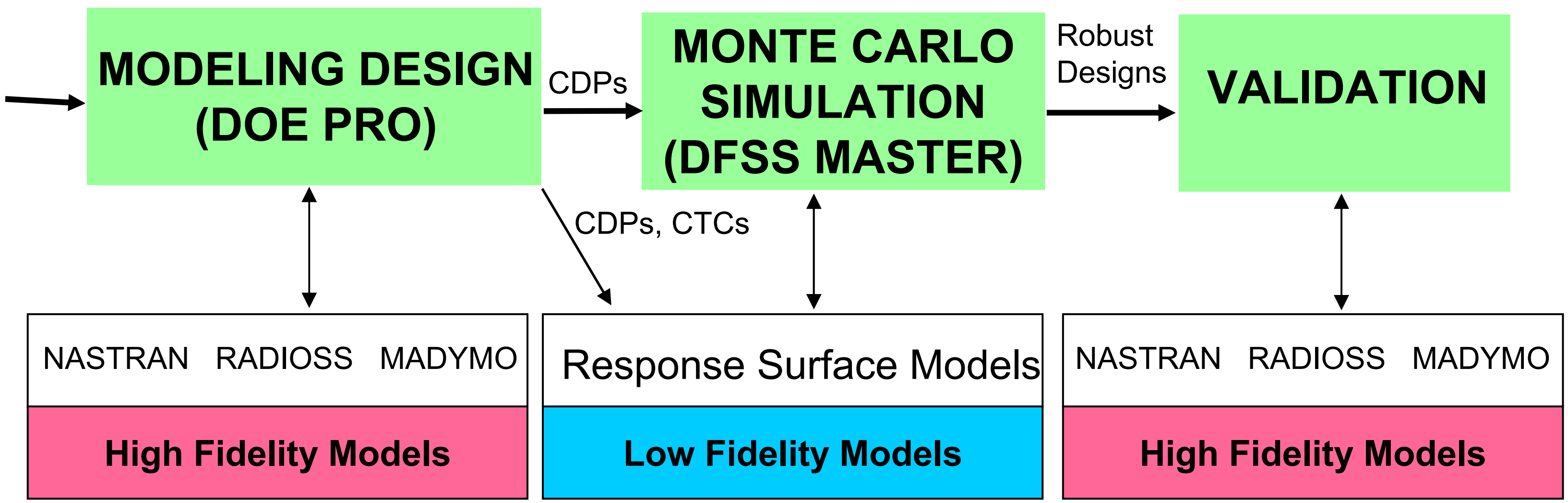
Applying Modeling and Simulation to Automotive Vehicle Design (cont.)



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Introduction to High Throughput Testing (HTT)

- A recently developed technique based on combinatorics
- Used to test myriad combinations of many factors (typically qualitative) where the factors could have many levels
- Uses a minimum number of runs or combinations to do this
- Software (e.g., ProTest) is needed to select the minimal subset of all possible combinations to be tested so that all n-way combinations are tested.
- HTT is not a DOE technique, although the terminology is similar
- A run or row in an HTT matrix is, like DOE, a combination of different factor levels which, after being tested, will result in a successful or failed run
- HTT has its origins in the pharmaceutical business where in drug discovery many chemical compounds are combined together (combinatorial chemistry) at many different strengths to try to produce a reaction.
- Other industries are now using HTT, e.g., software testing, materials discovery, interoperability testing, IT (see IT example on next page)

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HTT Example

- An IT function in a company wanted to test all 2-way combinations of a variety of computer configuration-related options or levels to see if they would function properly together.
- Here are the factors with each of their options:

Motherboards (5)	:	Gateway, ASUS, Micronics, Dell, Compaq
RAM (3)	:	128 MB, 256 MB, 512 MB
BIOS (3)	:	Dell, Award, Generic
CD (3)	:	Generic, Teac, Sony
Monitor (5)	:	Viewsonic, Sony, KDS, NEC, Generic
Printer (3)	:	HP, Lexmark, Cannon
Voltage (2)	:	220, 110
Resolution (2)	:	800x600, 1024x768

- How many total combinations are there?
- What is the minimum number of these combinations we will have to test (and which ones are they) in order to determine if every 2-way combination (e.g., Dell Bios with Teac CD) will indeed work properly together?
- To answer this question, we used Pro-Test software. The answer is 25 runs and those 25 combinations are shown on the next page.

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High Throughput Testing (HTT)

(for all two-way combinations)

	Motherboard (5 Levels)	RAM (3 Levels)	BIOS (3 Levels)	CD (3 Levels)	Monitor (5 Levels)	Printer (3 Levels)	Voltage (2 Levels)	Resolution (2 Levels)
Case 1	ASUS	256 MB	Dell	Generic	Viewsonic	Lexmark	110 V	800 x 600
Case 2	Compaq	512 MB	Dell	Teac	Sony	HP	220 V	1024 x 768
Case 3	Gateway	128 MB	Generic	Sony	KDS	Cannon	220 V	800 x 600
Case 4	Dell	128 MB	Award	Teac	NEC	Cannon	110 V	1024 x 768
Case 5	Micronics	256 MB	Generic	Teac	Generic	Lexmark	220 V	1024 x 768
Case 6	Gateway	256 MB	Award	Sony	Sony	HP	110 V	1024 x 768
Case 7	Micronics	512 MB	Award	Generic	Viewsonic	Cannon	220 V	1024 x 768
Case 8	ASUS	512 MB	Generic	Teac	KDS	HP	220 V	1024 x 768
Case 9	Compaq	128 MB	Award	Generic	Generic	HP	110 V	800 x 600
Case 10	Micronics	512 MB	Generic	Teac	Sony	Lexmark	110 V	800 x 600
Case 11	Dell	256 MB	Award	Generic	KDS	Lexmark	110 V	1024 x 768
Case 12	Gateway	512 MB	Dell	Sony	Generic	Lexmark	110 V	1024 x 768
Case 13	Compaq	256 MB	Generic	Sony	Viewsonic	Cannon	220 V	1024 x 768
Case 14	ASUS	128 MB	Dell	Sony	NEC	Cannon	220 V	800 x 600
Case 15	Micronics	128 MB	Dell	Sony	KDS	Lexmark	220 V	800 x 600
Case 16	Gateway	128 MB	Generic	Teac	Viewsonic	HP	110 V	800 x 600
Case 17	Dell	128 MB	Dell	Sony	Sony	Cannon	110 V	1024 x 768
Case 18	ASUS	256 MB	Award	Sony	Generic	Cannon	220 V	1024 x 768
Case 19	Compaq	512 MB	Dell	Sony	NEC	Lexmark	110 V	800 x 600
Case 20	Gateway	256 MB	Generic	Generic	NEC	Cannon	220 V	800 x 600
Case 21	Micronics	512 MB	Generic	Teac	NEC	HP	220 V	800 x 600
Case 22	ASUS	256 MB	Generic	Generic	Sony	HP	110 V	800 x 600
Case 23	Dell	512 MB	Generic	Sony	Viewsonic	HP	220 V	1024 x 768
Case 24	Compaq	256 MB	Dell	Generic	KDS	Cannon	220 V	1024 x 768
Case 25	Dell	128 MB	Generic	Sony	Generic	HP	110 V	800 x 600

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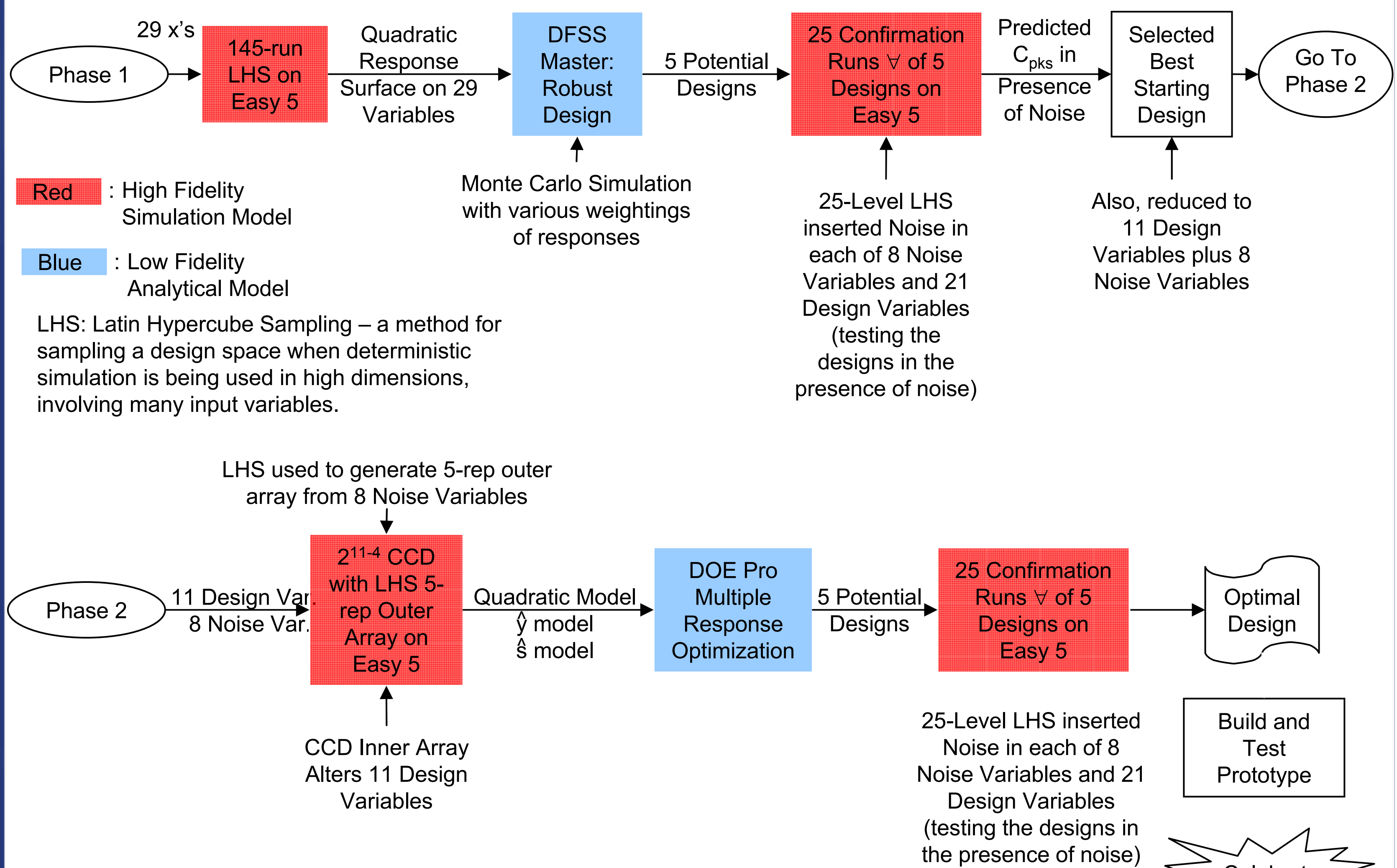
Example of Iterative Approach to Modeling and Simulation to Optimize Transmission Performance



Used with permission from John Deere

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Technologies Used on Transmission Project

- **High Throughput Testing (HTT)**

  To generate a minimal number of test cases; in this scenario, 11 combinations of 29 variables that would allow testing all two-way combinations on Easy 5. This made running the Easy 5 simulator much easier, without interruption.

- **DFSS Master: for Robust Design and Expected Value Analysis (Monte Carlo Techniques)**

- **Highly Orthogonal Latin Hypercube Sampling**

  To populate the design space with test cases which are highly orthogonal. Typically used with deterministic simulation to screen out the CDPs and also to use modeling DOEs on the simulator to generate transfer functions which characterize the simulator

- **DOE PRO: for Multiple Response Optimization**

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Summary of "Modeling the Simulator"

Perform Screening Design Using the Simulator if necessary

↓ Critical Parameters ID'd

Perform Modeling Design Using the Simulator to Build Low Fidelity Model

↓ Transfer Function on Critical Parameters

Perform Expected Value Analysis, Robust Design, and Tolerance Allocation Using Transfer Function

↓ Optimized Design

Validate Design Using the Simulator

↓ Optimized Simulator

Build Prototype to Validate Design in Real World

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Environments Where Simulation and Modeling Is Beneficial

- **A high number of design variables**
- **A substantial number of design subsystems and engineering disciplines**
- **Interdependency and interaction between the subsystems and variables**
- **Multiple response variables**
- **Need to characterize the system at a higher level of abstraction**
- **Time and/or space must be compressed**

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NDIA Test & Evaluation Conference

Producing Anywhere, Anytime Test, Evaluation and Diagnostics Capable Products to Eliminate the T&E Logistic Burden

Ryan Kinney
Fault Detective Product Manager
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Introduction

What is Agilent?

- Although Agilent sells a diverse number of products, my part of the company designs, manufactures, and sells <u>extremely complicated & state-of-the-art</u> RF instruments
- Even though we are an industry leader and our core competency is test & measurement, we struggle with “sustainment”

Who am I?

- I am the product manager for an Agilent software product named Fault Detective
- My background is software development

What is “Anywhere, Anytime Diagnostics”?

Anywhere

A single diagnostics technology used across the entire product lifecycle

1. Manufacturing/production
2. Service centers/depots
3. In the field (Both remote and local)

Anytime

Fast, accurate diagnostics regardless of location and operator skill

Agilent Vision

- One of our instruments fails on a customer’s manufacturing line… halting production
- The instrument self-diagnoses and notifies an Agilent service center
- An Agilent repair technician contacts the customer knowing exactly how to fix the problem

A/D Vision

- A failure occurs on a jet in mid-flight
- The jet self-diagnoses and communicates the failure to a ground crew
- The ground crew is prepared by the time the jet lands

"Anywhere, Anytime Diagnostics" in Action

Two Agilent instruments are equipped with "Anywhere, Anytime Diagnostics":

E6601A Wireless Communications Test Set

Functionality of a base station

Number of printed circuit assemblies: 7

Number of interconnects: 16

Push a button and the instrument automatically troubleshoots itself.

N9020A MXA Spectrum Analyzer

Frequency range: 20 Hz to 26.5 GHz

Number of printed circuit assemblies: 12

Number of interconnects: 25

Challenges We Faced

1. **Design a product with adequate diagnosability**
   If a product is too difficult to repair, any sustainment strategy will be a challenge. Typically, diagnosability is not known until production, when it's often too late to fix the problem.

2. **Create a test plan with appropriate coverage & diagnostic resolution**
   Poor test coverage puts faulty products in the field. Poor diagnostic resolution produces test results that provide little insight into failures. Quantifying the effectiveness of functional test is notoriously difficult, making it hard to know when your test process is "good enough".

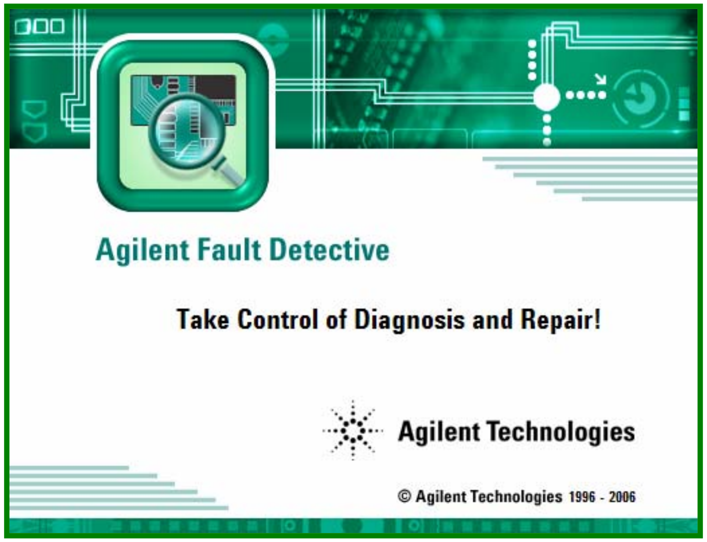
3. **Automate trouble-shooting**
   A worthy goal, but difficult to achieve without a lot of investment.

4. **Embed the entire solution in the product**
   How do you create an effective test solution without any external test equipment?

Agilent Fault Detective Software

Q: The issues on the previous slide are really tough to address, so how did we do it?

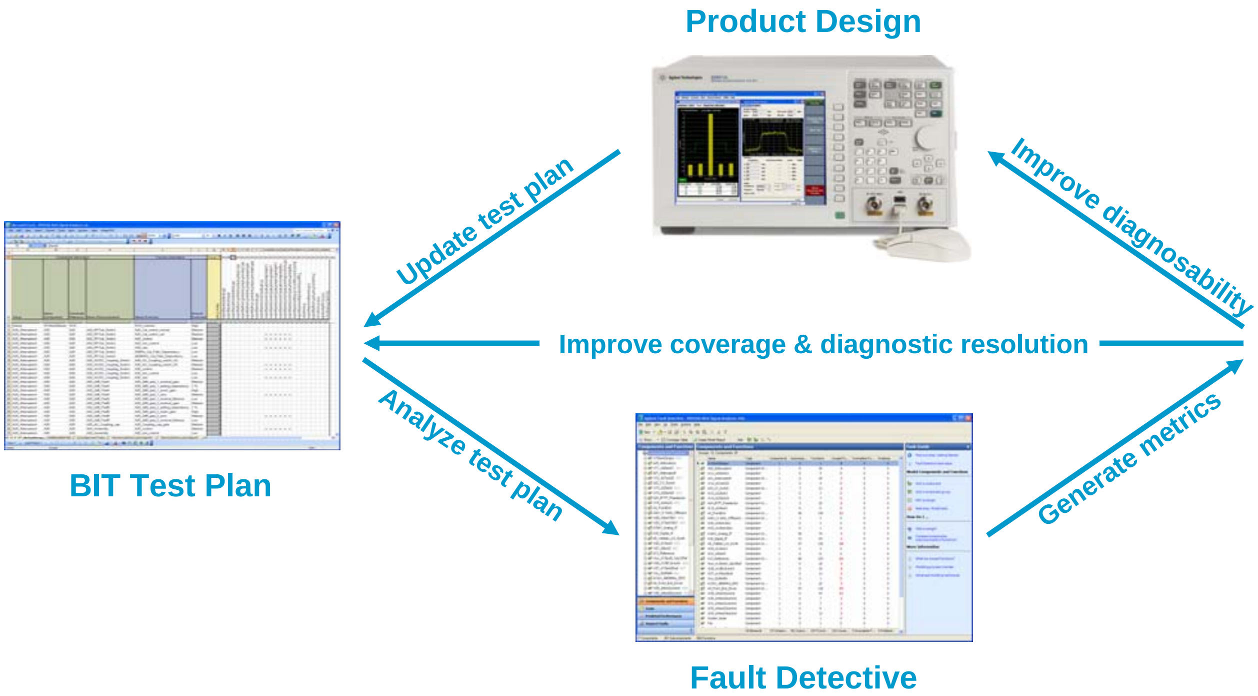
A: We used an in-house software tool named *Fault Detective.*



***Fault Detective*:**

1. Create/document your test plan
2. Assesses the effectiveness of a functional test plan
3. Assesses the diagnosability of a product
4. Automatically troubleshoots defective products

Process Overview



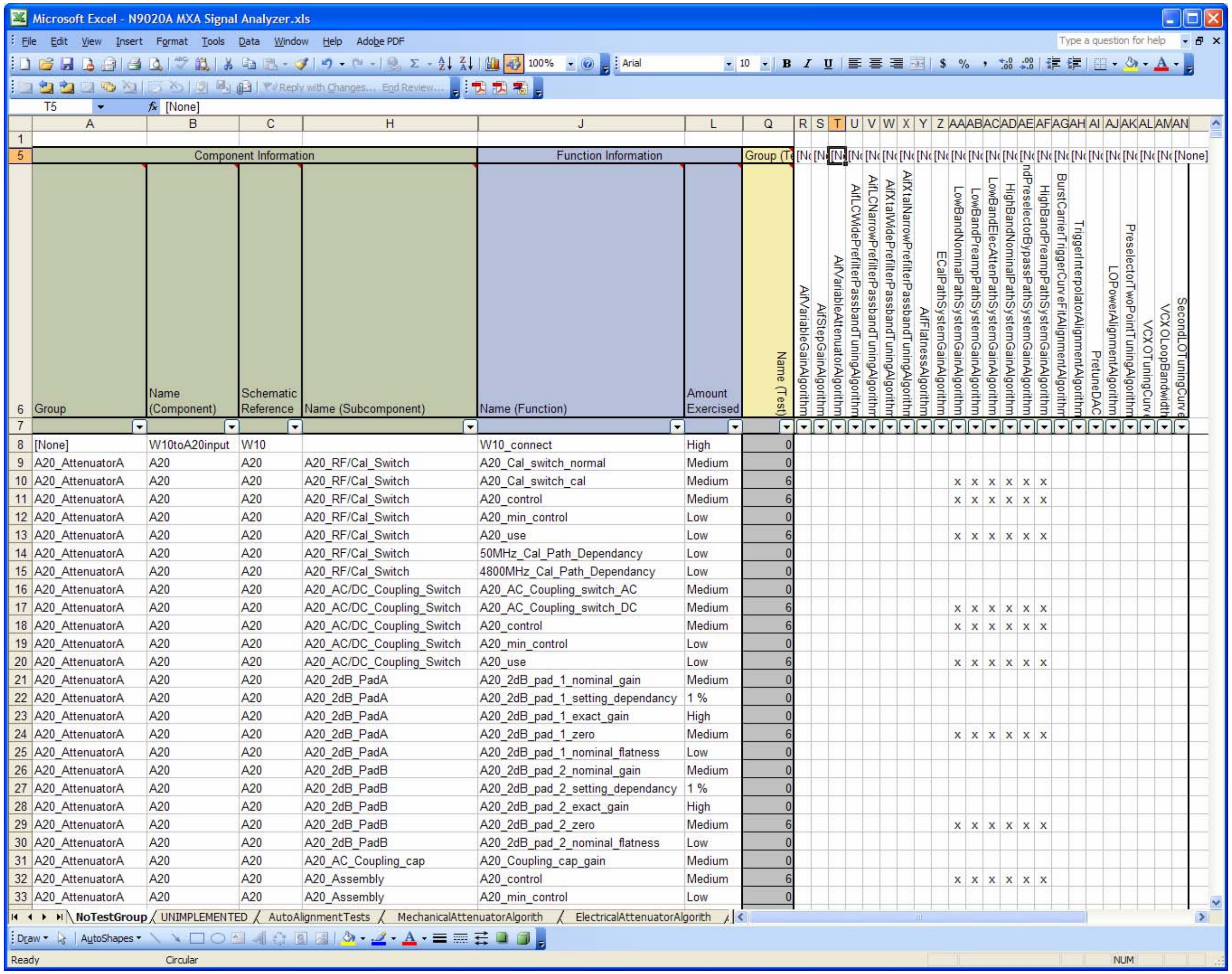
Two Key Metrics

1. **Detection**
   How well do I detect failures during functional test
2. **Isolation**
   If a product fails functional test, how much effort is required to troubleshoot

Process Overview

1. Create/capture test plan in Fault Detective
2. Analyze the test plan in Fault Detective to generate metrics
3. Use metrics to improve product diagnosability
4. Use metrics to improve test coverage and diagnostics resolution

Creating/Documenting Your Test Plan



Microsoft Excel - N9020A MXA Signal Analyzer.xls

	A	B	C	H	J	L	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1																														
5	Component Information				Function Information		Group (Te	[Nc	[N	[N	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[Nc	[None]
6	Group	Name (Component)	Schematic Reference	Name (Subcomponent)	Name (Function)	Amount Exercised	Name (Test)	AifVariableGainAlgorithm	AifStepGainAlgorithm	AifVariableAttenuatorAlgorithm	AifLCWidePrefilterPassbandTuningAlgorithm	AifLCNarrowPrefilterPassbandTuningAlgorithm	AifXtalWidePrefilterPassbandTuningAlgorithm	AifXtalNarrowPrefilterPassbandTuningAlgorithm	AifFlatnessAlgorithm	ECalPathSystemGainAlgorithm	LowBandNominalPathSystemGainAlgorithm	LowBandPreampPathSystemGainAlgorithm	LowBandElecAttenPathSystemGainAlgorithm	HighBandNominalPathSystemGainAlgorithm	ndPreselectorBypassPathSystemGainAlgorithm	HighBandPreampPathSystemGainAlgorithm	BurstCarrierTriggerCurveFitAlignmentAlgorithm	TriggerInterpolatorAlignmentAlgorithm	PretuneDAC	LOPowerAlignmentAlgorithm	PreselectorTwoPointTuningAlgorithm	VCXOTuningCurv	VCXOLoopBandwidth	SecondLOTuningCurv
7																														
8	[None]	W10toA20input	W10		W10_connect	High	0																							
9	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_Cal_switch_normal	Medium	0																							
10	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_Cal_switch_cal	Medium	6										x	x	x	x	x	x								
11	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_control	Medium	6										x	x	x	x	x	x								
12	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_min_control	Low	0																							
13	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_use	Low	6										x	x	x	x	x	x								
14	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	50MHz_Cal_Path_Dependancy	Low	0																							
15	A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	4800MHz_Cal_Path_Dependancy	Low	0																							
16	A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_AC_Coupling_switch_AC	Medium	0																							
17	A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_AC_Coupling_switch_DC	Medium	6										x	x	x	x	x	x								
18	A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_control	Medium	6										x	x	x	x	x	x								
19	A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_min_control	Low	0																							
20	A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_use	Low	6										x	x	x	x	x	x								
21	A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_nominal_gain	Medium	0																							
22	A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_setting_dependancy	1 %	0																							
23	A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_exact_gain	High	0																							
24	A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_zero	Medium	6										x	x	x	x	x	x								
25	A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_nominal_flatness	Low	0																							
26	A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_nominal_gain	Medium	0																							
27	A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_setting_dependancy	1 %	0																							
28	A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_exact_gain	High	0																							
29	A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_zero	Medium	6										x	x	x	x	x	x								
30	A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_nominal_flatness	Low	0																							
31	A20_AttenuatorA	A20	A20	A20_AC_Coupling_cap	A20_Coupling_cap_gain	Medium	0																							
32	A20_AttenuatorA	A20	A20	A20_Assembly	A20_control	Medium	6										x	x	x	x	x	x								
33	A20_AttenuatorA	A20	A20	A20_Assembly	A20_min_control	Low	0																							

NoTestGroup / UNIMPLEMENTED / AutoAlignmentTests / MechanicalAttenuatorAlgorith / ElectricalAttenuatorAlgorith

Ready Circular NUM

Key Benefits

Standardized process for documenting functional test.

Step 1
List tests

Step 2
List hardware components (nouns)

Step 3
List functionality (verbs) of each hardware component

Step 4
For each function, assign “amount of component exercised” (High, Medium or Low)

Step 5
For each test, put an ‘X’ for the functions it exercises

Assessing Functional Test & Product Diagnosability

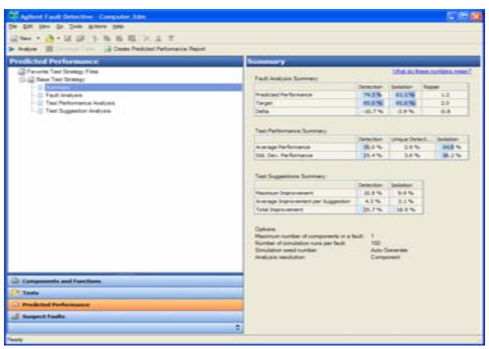
Key Benefit

Using the model, Fault Detective generates metrics needed to:

1. Improve the product: *diagnosability*
2. Improve functional test: *coverage & diagnostics resolution*

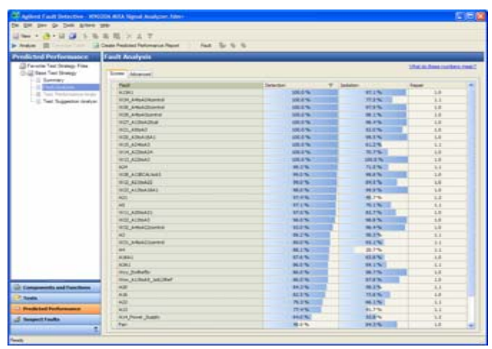
Summary

1. Overall, how likely are test escapes?
2. Overall, how difficult is it to troubleshoot this product?



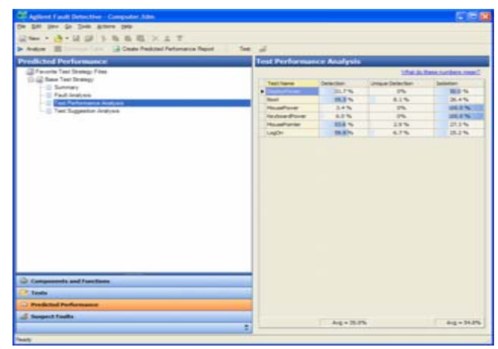
Fault Analysis

1. How likely are specific failures to escape?
2. How difficult is it to troubleshoot specific failures?

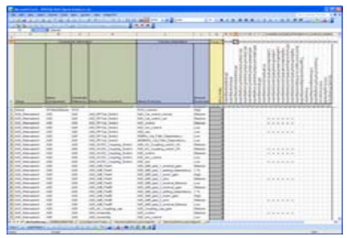


Test Performance Analysis

1. How good is a specific test at catching escapes?
2. How much does a test contribute to diag resolution?



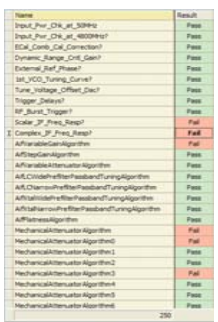
Automating Diagnostics



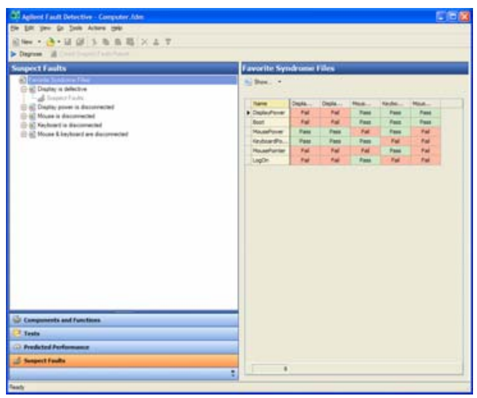
Fault Detective Model

Key Benefit

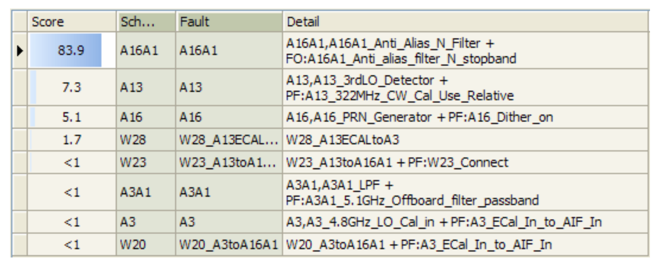
Automated diagnostics are fast & accurate, yielding consistent results, and can be embedded directly in the product.



Test Results



Fault Detective Diagnostics Engine



Score	Sch...	Fault	Detail
83.9	A16A1	A16A1	A16A1,A16A1_Anti_Alias_N_Filter + FO:A16A1_Anti_alias_filter_N_stopband
7.3	A13	A13	A13,A13_3rdLO_Detector + PF:A13_322MHz_CW_Cal_Use_Relative
5.1	A16	A16	A16,A16_PRN_Generator + PF:A16_Dither_on
1.7	W28	W28_A13ECAL...	W28_A13ECALtoA3
<1	W23	W23_A13toA1...	W23_A13toA16A1 + PF:W23_Connect
<1	A3A1	A3A1	A3A1,A3A1_LPF + PF:A3A1_5.1GHz_Offboard_filter_passband
<1	A3	A3	A3,A3_4.8GHz_LO_Cal_in + PF:A3_ECal_In_to_AIF_In
<1	W20	W20_A3toA16A1	W20_A3toA16A1 + PF:A3_ECal_In_to_AIF_In

Diagnosis

Summary of Benefits/Results

Near 100 percent diagnostic accuracy

Incremental effort is minimal (for A/D, coverage requirement is mandatory on most programs)… "it's a no-brainer"

Manufacturing/Production

Perform self-diagnosis after final assembly, before final verification.

1. Standardized test documentation → Consistency across the company
2. Coverage assessment → Fewer test escapes
3. Diagnostics assessment → Predictable time-to-volume
4. Automated diagnostics → Fewer resource requirements (fewer repair technicians & less capital equipment)
   → IP protection

Service Centers/Depots

Perform self-diagnosis before manual troubleshooting.

1. Automated diagnostics → Fewer resource requirements (less time ramping-up technicians at each service depot)
   → Faster turn-around time
2. Coverage assessment → Fewer no-trouble-founds

In the Field

Peform diagnostic from anywhere in the world.

1. Automated diagnostics → Fewer resource requirements
   → Increased product up-time
2. Coverage assessment → Fewer failures in the field

AFOTEC

AIR FORCE OPERATIONAL TEST & EVALUATION CENTER






Approved for public release, distribution unlimited

AFOTEC's Perspective on Operational Suitability Testing

Mr Jerry Kitchen
AFOTEC/CA

Presentation date: 13 Mar 2007
Release date: 4 Mar 2007

Overview

- Myth Busters
- What's Changed?
- Suitability – An Afterthought?
- Operational Test Construct
- Acquisition Efficiencies

Myth Busters

- New rating scheme – no more E&S

Myth Busters

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- E only – it's all about effectiveness

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- Stoplight chart – no objective analysis

Myth Busters

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- E only – it's all about effectiveness
- 'ilities – things of the past
- Stoplight chart – no objective analysis

MYTHS BUSTED!

What's Changed?

- Customer-focused reports
  - Accurate, balanced, complete, clear, concise, cogent, and timely
  - Warfighter community
    - Can a unit equipped with the weapon system accomplish the mission?
  - Acquisition community
    - Is the weapon system effective and suitable?
- Capability-based OT&E
  - No longer "Pass / Fail"
    - Effective / suitable with limitations impacting operations
  - Mission Capability Rating

Mission Capability Ratings

MC RATING	DEFINITION
FULLY MISSION CAPABLE (FMC) B	Mission can be accomplished in the intended operational environment
MISSION CAPABLE (MC) G	Mission can be accomplished, but with increased operational cost
PARTIALLY MISSION CAPABLE (PMC) Y	Only some aspects of mission can be accomplished <u>And/Or</u> Mission can only be accomplished under some conditions
NOT MISSION CAPABLE (NMC) R	Mission cannot be satisfactorily accomplished
NOT RESOLVED	Insufficient information to support a resolution

Suitability – An Afterthought?

- U.S. Code Title 10 requires AFOTEC to determine BOTH operational effectiveness and operational suitability
- Operational effectiveness is the overall degree of mission accomplishment of a system … (DAG 9.4.4)
- Operational suitability is the degree to which a system can be satisfactorily placed in field use, with consideration given to reliability, … (DAG 9.4.5)
- AFOTEC fulfills this mandate through the Operational Test Construct

Operational Test Construct

- Methodical, repeatable test construct is crucial for accurate, balanced, and complete reports
  - Foundation for all follow-on planning, evaluation, and reporting activities
  - Must capture CONOPS, desired capabilities, and defined requirements found in capability documents
- Extremely challenging test team activity
  - Involves participants across acquisition community
    - Each brings own perspectives, priorities, and agendas
- Test Constructs must use clearly defined terminology

A poorly built test construct today will ultimately produce bad reports years down the road

DAG "OT&E Best Practices"

1. Focus on the mission(s) that will be accomplished
2. Identify the operational capabilities
3. Develop measures and data requirements
4. Assess the degree of mission accomplishment
5. Link mission accomplishment to the key operational capabilities

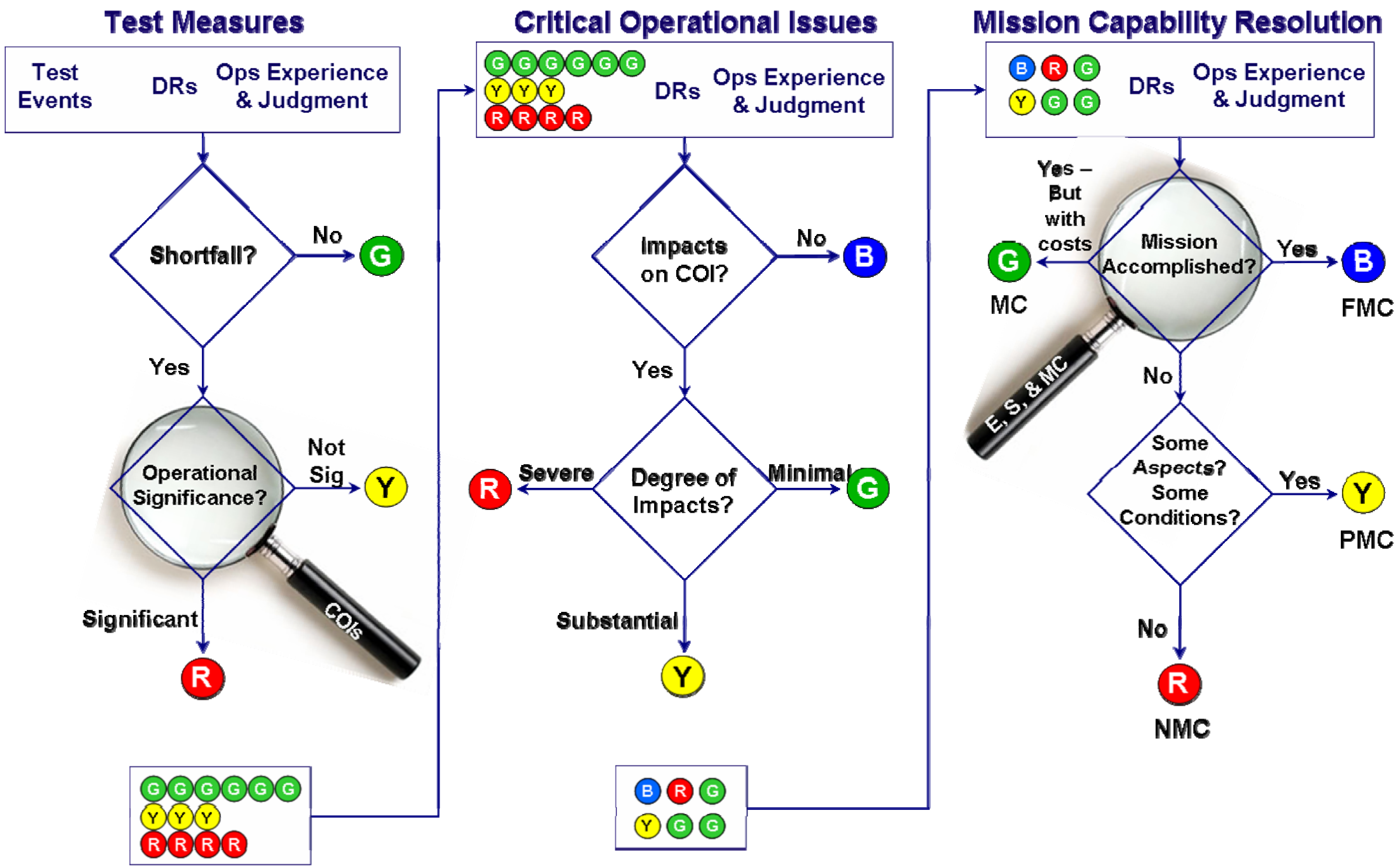
Defense Acquisition Guidebook, Ver 1.6, Chapter 9.8.2, 07/24/2006

AFOTEC Test Construct

Mission Statement

Operational Capability	COI 1	COI 2	COI 3	
Timeliness		●		Effectiveness
Lethality			●	
Accuracy	●	●		
Survivability		●		
Maneuverability	●			
Capacity	●			
Transportability		●	●	Suitability
Sustainability	●			
Interoperability			●	
Maintainability	●			
Availability			●	
Reliability		●		

Evaluation Taxonomy



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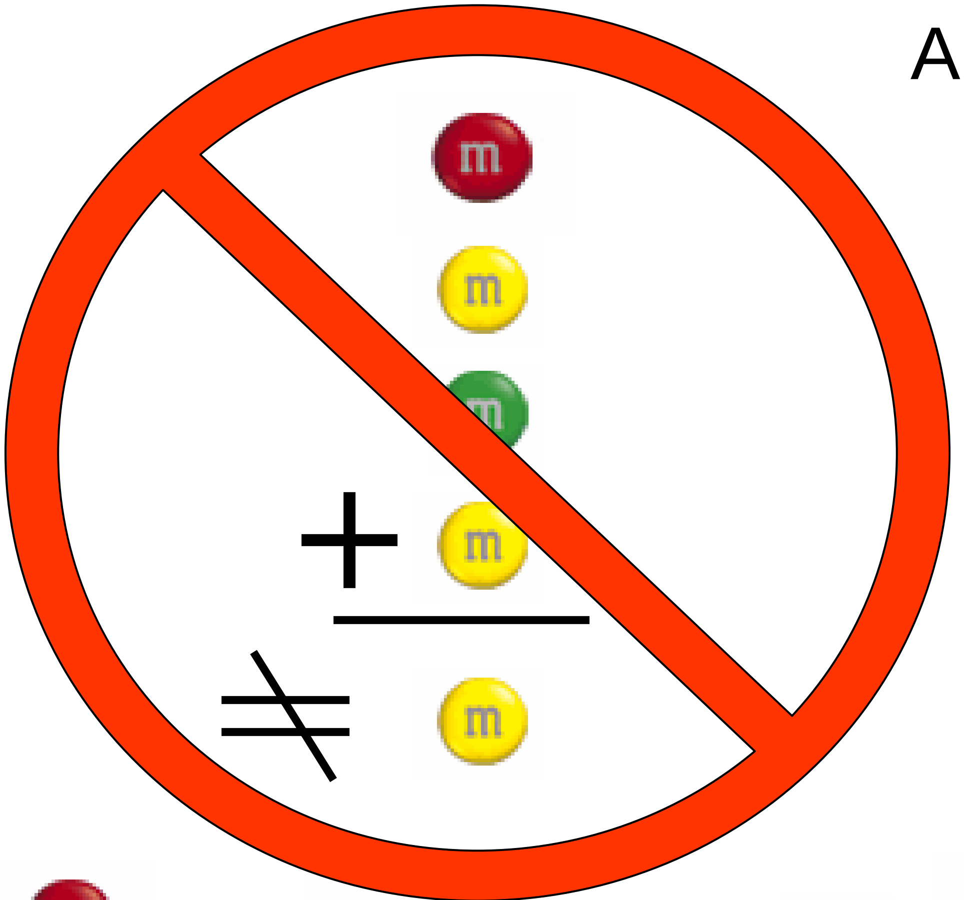
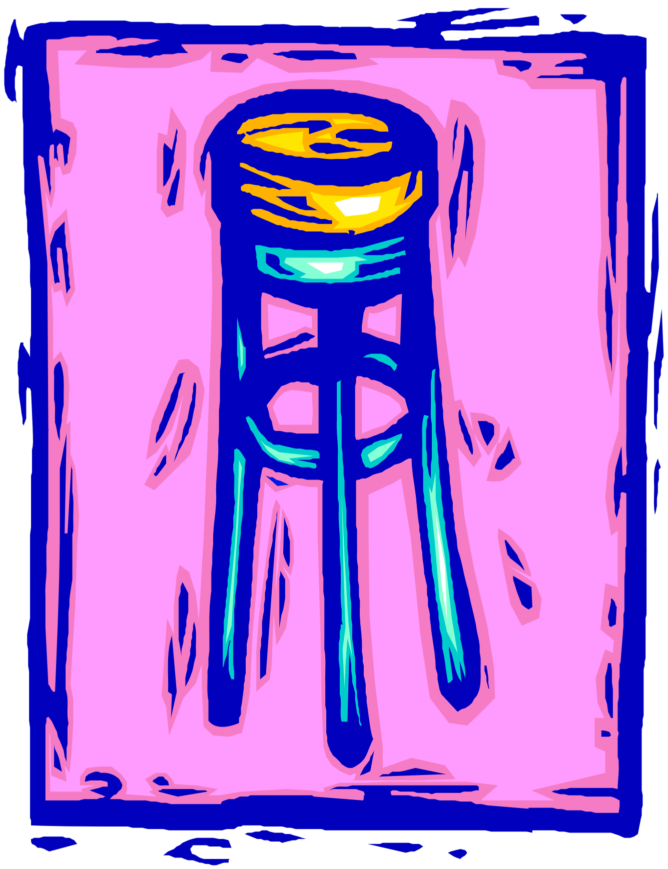


AFOTEC Construct is not designed to facilitate m&m math

Colors are intended to visually display (1) significance of shortfalls, (2) degree of impact on COIs, and (3) overall Mission Capability Resolution

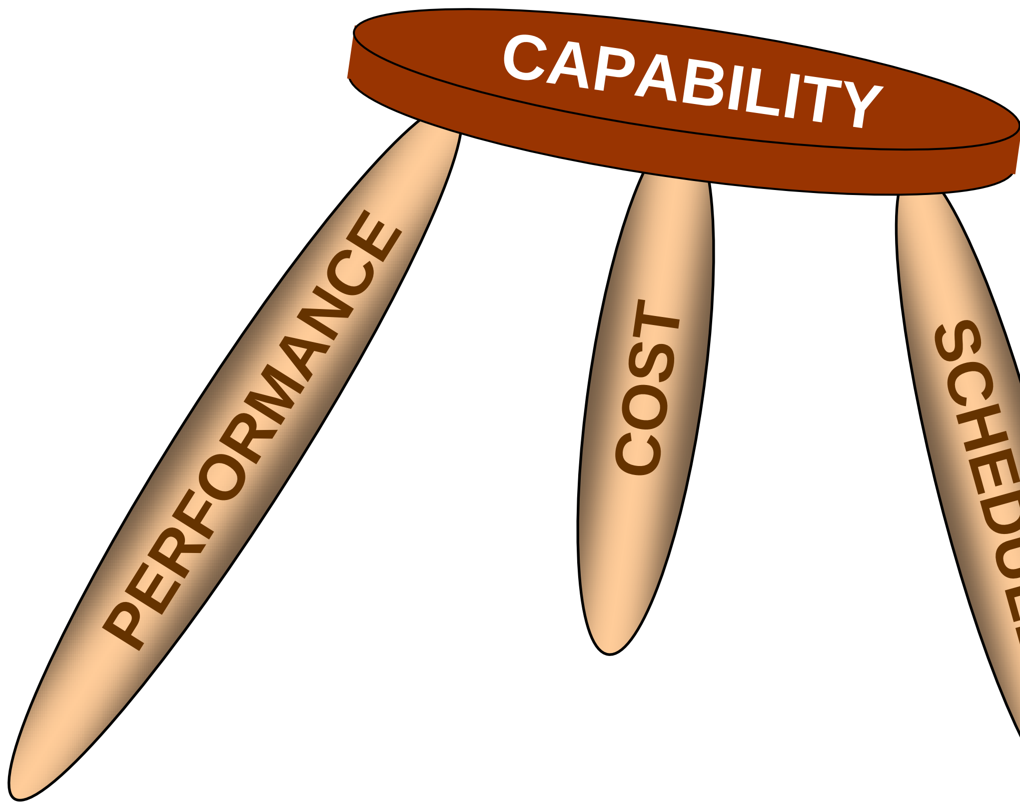
Delivering Capability

- Capability stool is supported by three legs
  - Cost
  - Schedule
  - Performance
- Current acquisition philosophies make for a very shaky stool
  - Promise the moon
  - Technology “creep” and “reach”
  - Get it now, fix it later
  - Fear of failure
  - Rush to failure



The Promise

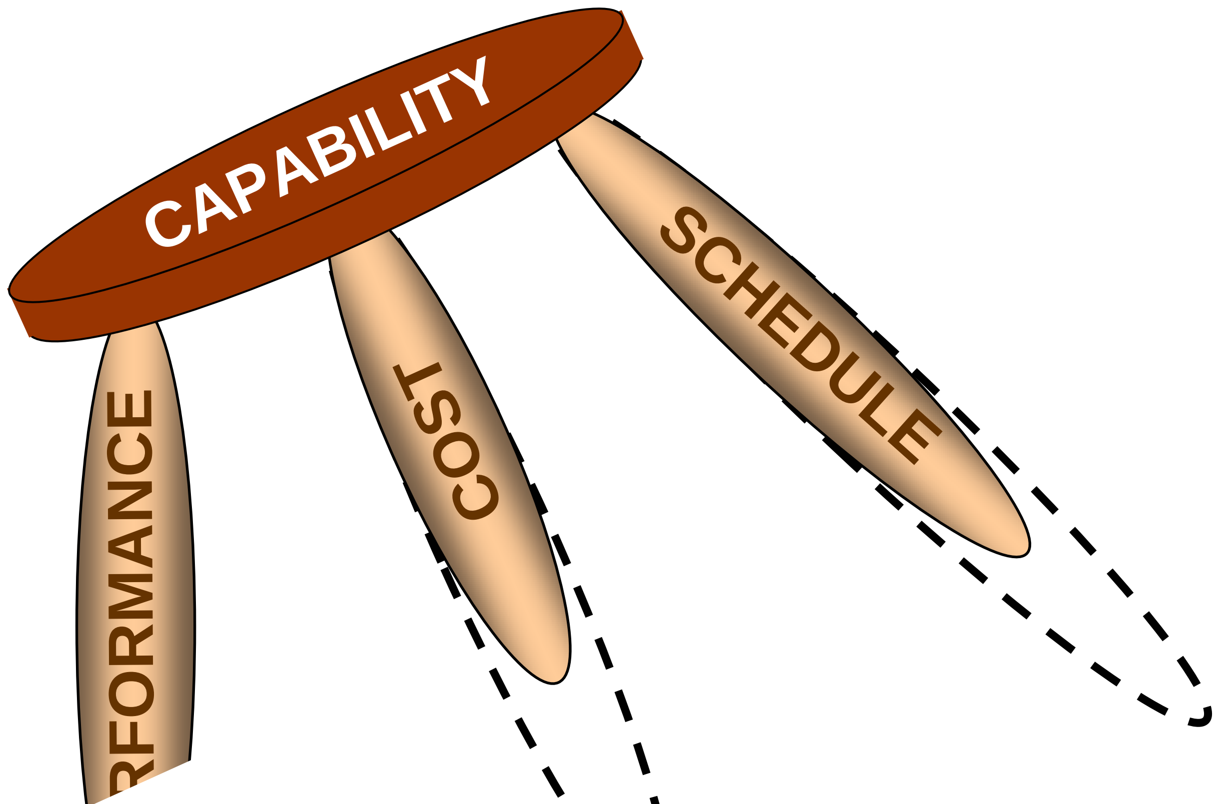
Give the warfighter the tools to get the job done



Desired performance, on time, on budget

The Reality

Schedule slips, cost overruns, performance deferred



BREACH!!!

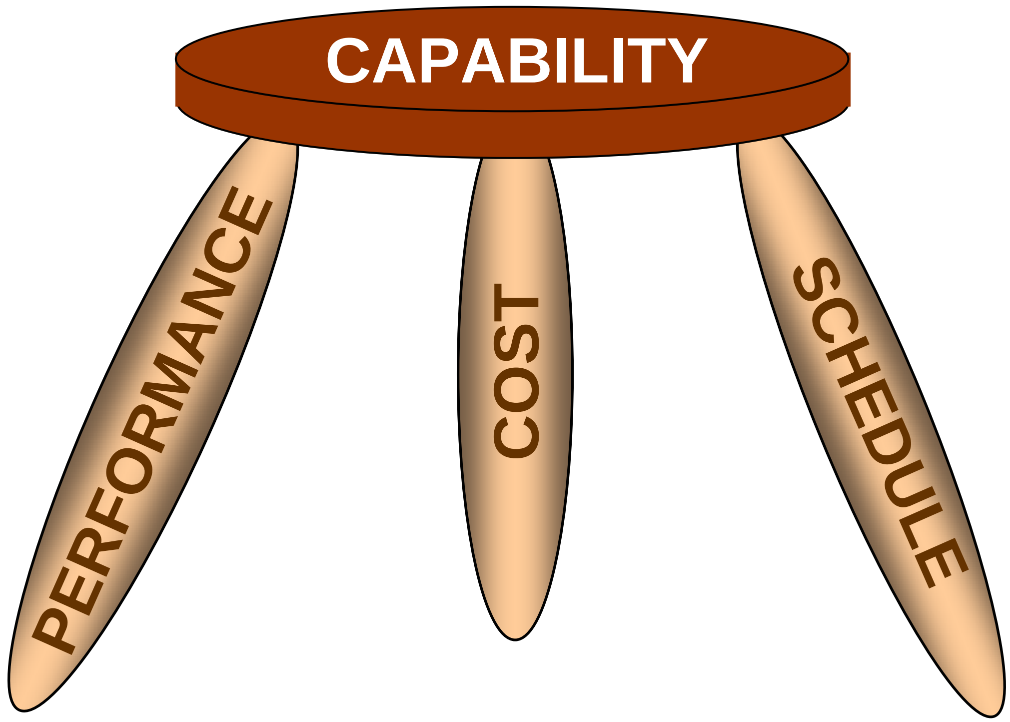
Fail to Deliver

Fail to design, build, field, and sustain capable weapon systems

The Air Force weapons acquisition process is not credible

Truth in Advertising

Acquire weapon systems in attainable, capable increments



Under promise, over deliver!

Warfighter Focused!

Joint Mission Environment Test Capability (JMETC)

23rd Annual National Test and Evaluation Conference

Mr. Richard Lockhart
Principal Deputy Director
Test Resource Management Center (TRMC)

March 13, 2007

TRMC Functions

Sec. 231, FY 2003 National Defense Authorization Act
DoD Directive 5105.71, March 8, 2004

- **DoD Field Activity**
- **Direct Report to USD(AT&L)**

SES Director

MRTFB Policy Oversight

Biennial 10-Year Strategic Planning

Annual T&E Budget Certification (Military Departments and DoD Agencies)

T&E Workforce

Administer T&E Investment Programs (CTEIP, T&E/S&T, JMETC)

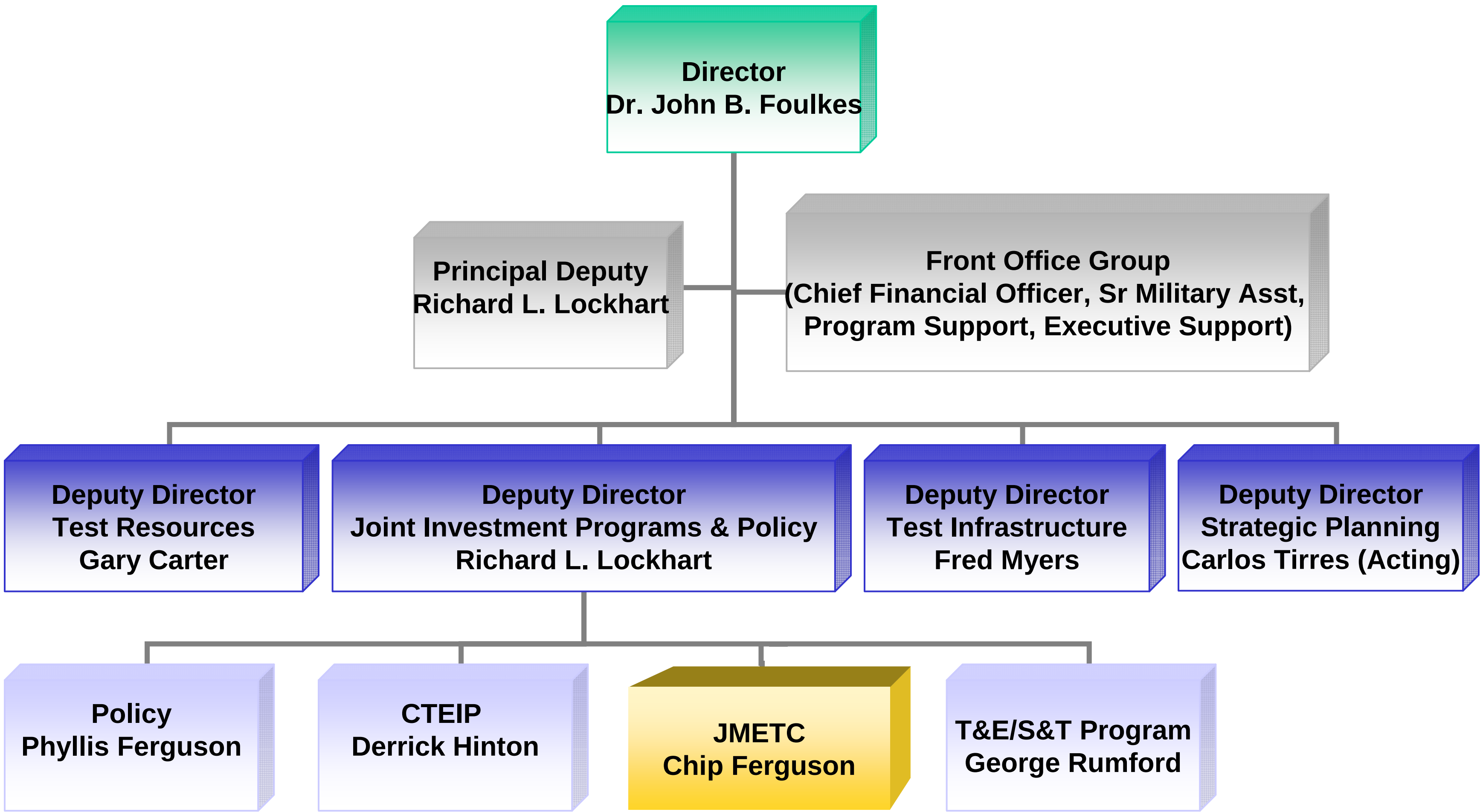
Oversee T&E Budgets and Infrastructure (MRTFB and other test facilities)

TRMC Vision

"The Department of Defense T&E Ranges and Facilities will be fully capable of supporting the Department with quality products and services in a responsive and affordable manner."

We are the stewards of the T&E Infrastructure

TRMC Organization



Testing in a Joint Environment
Background

- **March 2004** – SPG: “Joint Testing in Force Transformation”
  - Policy – *Developing and fielding joint force capabilities requires adequate, realistic test and evaluation in a joint operational context*
  - Direction – *DoD will provide new testing capabilities and institutionalize the evaluation of joint system effectiveness*
  - Action – DOT&E lead development of a Roadmap to define changes *to ensure that T&E is conducted in a joint environment and facilitates the fielding of joint capabilities*
- **November 2004** – DEPSECDEF approved Roadmap, validated SPG
- **December 2005** – PB07 PDM approved Change Proposal
  - Joint Mission Environment Test Capability (JMETC) Program Element under USD(AT&L)/ TRMC for execution
- **FY 2006** – Conducted five capability demonstrations of JMETC
- **October 2006** – Establishment of JMETC Program Management Office in Crystal City, VA

Distributed LVC Integration Challenges

- **Problem**
  - No corporate approach
  - Multiple unique solutions – AF-ICE, Navy DEP, JNTC
  - Multiple networks – DREN, DISN-LES, DATUMS
  - Multiple standards – TENA, HLA, DIS
  - Unique program-specific solutions for distributed LVC events
- **Impact**
  - Difficult, time-consuming to conduct distributed LVC events
  - Time consuming to establish security agreements
  - Costly duplication of infrastructure
  - Difficult to conduct joint testing
  - Difficult to integrate Test and Training

What is JMETC?

- A corporate approach for linking distributed facilities
  - Enables customers to efficiently evaluate their warfighting capabilities in a joint context
  - Provides compatibility between test and training
- A core, reusable, and easily reconfigurable foundation
  - Consists of the following products:
    - Persistent connectivity
    - Middleware
    - Standard interface definitions and software algorithms
    - Distributed test support tools
    - Data management solution
    - Reuse repository
  - Provides customer support services

JMETC Responsibility
Product Implementation and Sustainment

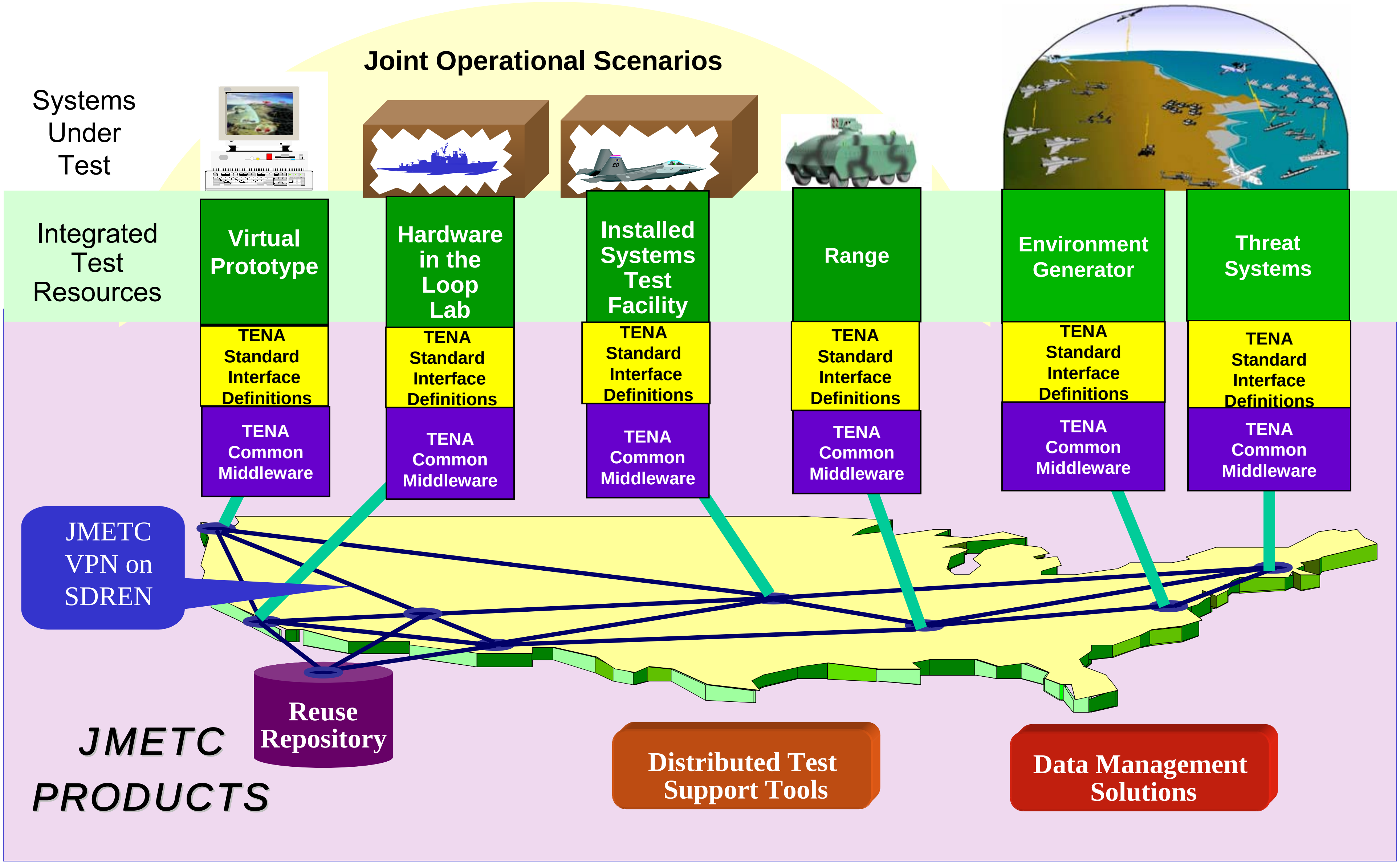
- **Persistent Connectivity:** Establish and maintain dedicated VPN on SDREN with standing security agreements.
- **Middleware:** Adopt and sustain downloadable TENA universal data exchange software.
- **Standard Interface Definitions & Software Algorithms:** Adopt and sustain downloadable TENA-established interface definitions and software algorithms (e.g., Radar, TSPI, coordinate and unit conversions, etc.).
- **Distributed Test Support Tools:** Collaborate with CTEIP and the Services to adopt and sustain InterTEC software tools and other existing software tool capabilities that meet JMETC customer needs.
- **Data Management Solutions:** Collaborate with CTEIP to develop new capabilities that meet JMETC customer needs.
- **Reuse Repository:** Establish and maintain on-line web portal with relevant distributed event information (latest middleware, software components, documentation, lessons learned, etc.).

Implementation dependent on funding and customer need

Test & Training Enabling Architecture (TENA)

- **TENA is:**
  - – Developed, upgraded, and sustained by CTEIP and JNTC
  - – Middleware that provides a single, universal data exchange solution
  - – Common for test and for training (core standard in JMETC and JNTC)
  - – Available for download at www.tena-sda.org for free
- **TENA provides:**
  - – Interoperability among range systems, hardware-in-the-loop laboratories, and simulations in a quick, cost-efficient manner
  - – A capability to rapidly and reliably develop LVC integrations
  - – A set of community-agreed object models that define the data elements used in LVC integrations – maximizes reuse from event to event
  - – An auto-code generator to drastically reduce TENA incorporation time
- **Next version of TENA (version 6.0) will:**
  - – Provide advanced data filtering (only data of interest sent over the wire)
  - – Improve fault tolerance and embedded diagnostics
  - – Be released in Fall 2007

JMETC Infrastructure



JMETC FY06 Prototype Demonstrations

- **InterTEC Spiral 1+**
  - Conducted Air Combat Mission Thread using Live (8 F-16, 2 F-22, 1 E-2C), Virtual (F-35, F/A-18, F-15, CVN), and Constructive (threats systems)
  - Linked 8 sites: Edwards, Eglin, Pt. Loma, Pt. Mugu, China Lake, Pax River, JITC, Fort Worth
  - Capability accredited by JITC as suitable for interoperability certification of F-35
- **Army 3CE**
  - Integrated M&S resources among 3 Army Commands (TRADOC, RDECOM, ATEC)
  - Linked different data exchange solutions (TENA and HLA) via gateway
  - Linked 6 sites: White Sands, Redstone, Aberdeen, Ft. Sill, Ft. Belvoir, Ft. Knox
- **Information Operations (IO) Range**
  - Distributed multiple video streams of IO effects from remote sites to JFCOM during the Austere Challenge '06 exercise
  - Linked 10 sites, and redistributed video to 35+ observation sites
- **Test & Training collaboration (Technical Alignment with JNTC)**
  - Demonstrated integration commonality with JNTC instrumentation used during Weapons & Tactics Instructor and Red Flag Alaska training exercises (as well as Talisman Sabre)
  - Linked 3 sites: Yuma, Quantico, Suffolk, plus two Alaskan ranges
  - Developed a TENA interface to GCCS (in <1 month) to display range data on GCCS

All events used TENA

Demonstrated the JMETC concept is viable and able to support distributed tests

JMETC Responsibility
Customer Support

JMETC supports customer needs at customer request

The JMETC Team:

- Assists in understanding JMETC and how to use it for testing
- Assists with T&E strategy and requirements
- Supports limited event planning, preparation, and execution
- Reviews and certifies JMETC products for corporate use
- Integrates new nodes onto JMETC VPN with security agreements
- Augments DREN with sites critical for joint testing (maximizing reuse)
- Measures JMETC infrastructure performance
- Provides Help Desk to assist JMETC product users
- Provides semi-annual TENA training classes

Prioritization of effort is based on funding available

Customer Responsibility

- **The customer is responsible for:**
  - Defining requirements
  - Providing test assets and resources
  - Requesting and funding field assistance:
    - Technical integration support, including site verification
    - JMETC product training
    - Detailed event planning, preparation, and execution
  - VPN usage fees for connectivity and bandwidth
  - Unique middleware, object model, and software tool development and upgrades
- **Sites not on JMETC VPN build plan may fund their own addition to JMETC infrastructure**

Industry Involvement

- **Two ways to become a part of the JMETC infrastructure:**
  - Being on government contract to support a program or test event using JMETC
  - Contact the JMETC Program Office
- **TENA middleware and object models freely available – over 27 companies members of TENA Architecture Management Team**
  - Technical forum providing open dialogue between users and TENA developers
  - Used to identify issues, vet concerns, debate solutions, and agree on way forward

Industry is a key component
in a successful DoD "corporate approach"
to linking distributed facilities

JMETC Leadership & Governance

JMETC
Chain of Command

Hon. Kenneth J. Krieg
USD(AT&L)

↕

Dr. John B. Foulkes
Director, Test Resource Management Center (TRMC)

Richard L. Lockhart
Principle Deputy, TRMC
Deputy Director, JIPP

↕

Chip Ferguson
JMETC Program Manager

↕

George Rumford
Systems Engineering Lead (Acting)

JMETC
Governance

JMETC Senior Leadership Group (SLG)

JMETC Advisory Group

JMETC Users Group

Membership

- JS J8 Co-Chair
- OSD TRMC Co-Chair
- DOT&E
- JFCOM
- JS J6
- Army
- Navy
- Air Force
- USMC
- (OUSD) P&R
- (OASD) NII
- (OSD) PA&E
- (OUSD) I
- DISA
- (OUSD) AT&L

JMETC Support Groups

- **JMETC Advisory Group**
  (GS-15/O-6-level headquarters representatives of T&E community)
  - Focuses is on overall program planning, direction, and priorities
  - Assists in identifying customers and priorities
  - Facilitates collaboration with Service initiatives

- **JMETC Users Group:**
  (Acquisition program offices, technical experts, and ranges that are potential users of JMETC infrastructure and products)
  - Focuses is on technical requirements and solutions
  - Makes recommendations to improve JMETC processes and procedures
  - Advises T&E community on TENA priorities prior to AMT meetings

JMETC FY07 Activities

- **Stand up the Program Management Office**
  - Fill positions
  - Develop Users' Guide and Long-Range Plan
- **Stand up JMETC Users Group**
- **Establish VPN based on customer requirements**
- **Support JCAS 07-03 event – JFCOM/JTEM/AF-ICE**
- **Support InterTEC Spiral 2-Build 1**
- **Support planning for FY08 customers and events**
  - InterTEC (Spiral 2-Build 2)
  - CVN-21
  - FCS
  - SIAP (JCHE-5)

JMETC Benefits

- **Provides Department-wide capability for:**
  - T&E of a weapon system in a joint context
  - DT, OT, Interoperability Certification, Net-Ready KPP compliance testing, Joint Mission Capability Portfolio testing, etc.
- **Provides test capability aligned with JNTC**
  - Both use TENA architecture
  - Enables joint test and training
- **Reduces time and cost by providing**
  - Readily available, persistent connectivity
  - Standing network security agreements
  - Object model auto-code generation tools
  - Tools that allow easy access to previous solutions and lessons learned
  - Corporate data exchange middleware
- **Provides Customer Support**
  - For JMETC products
  - For LVC distributed test expertise

The corporate solution to distributed LVC Testing

JMETC Points of Contact

Program Manager: Chip Ferguson
703-604-0350 x138
chip.ferguson@osd.mil

Systems Engineer: George Rumford
703-601-5233
george.rumford@osd.mil

Operations Planning: Len Zimmermann
703-604-0350 x141
leonard.zimmermann.ctr@osd.mil

Long Range Planning: Cynthia Lindberg-Ross
703-604-0350 x146
cynthia.lindberg-ross.ctr@osd.mil

Back-Up Slides

Industry Involvement

- **TENA solution is free**
  - Over 27 companies already members of TENA Architecture Management Team
- **Industry participation includes:**
  - AMTEC
  - Anteon Corporation
  - BAE Systems
  - BMH Associates
  - Boeing
  - Computer Sciences Corporation (CSC)
  - Cubic Defense
  - DRS Technologies
  - Electronic Warfare Associates (EWA)
  - Embedded Planet
  - EMC
  - Jacobs Engineering
  - Johns Hopkins University
  - Lockheed Martin
  - MAK Technologies
  - NetAcquire
  - Northrop Grumman
  - Raytheon
  - Samoff Cooporation
  - Science Applications International Corporation (SAIC)
  - Scientific Research Corporation (SRC)
  - Scientific Solutions, Inc. (SSI)
  - SRI, International
  - Trideum Corporation
  - Weibel
  - Wyle Laboratories
  - Virtual Technologies Corporation

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TARDEC

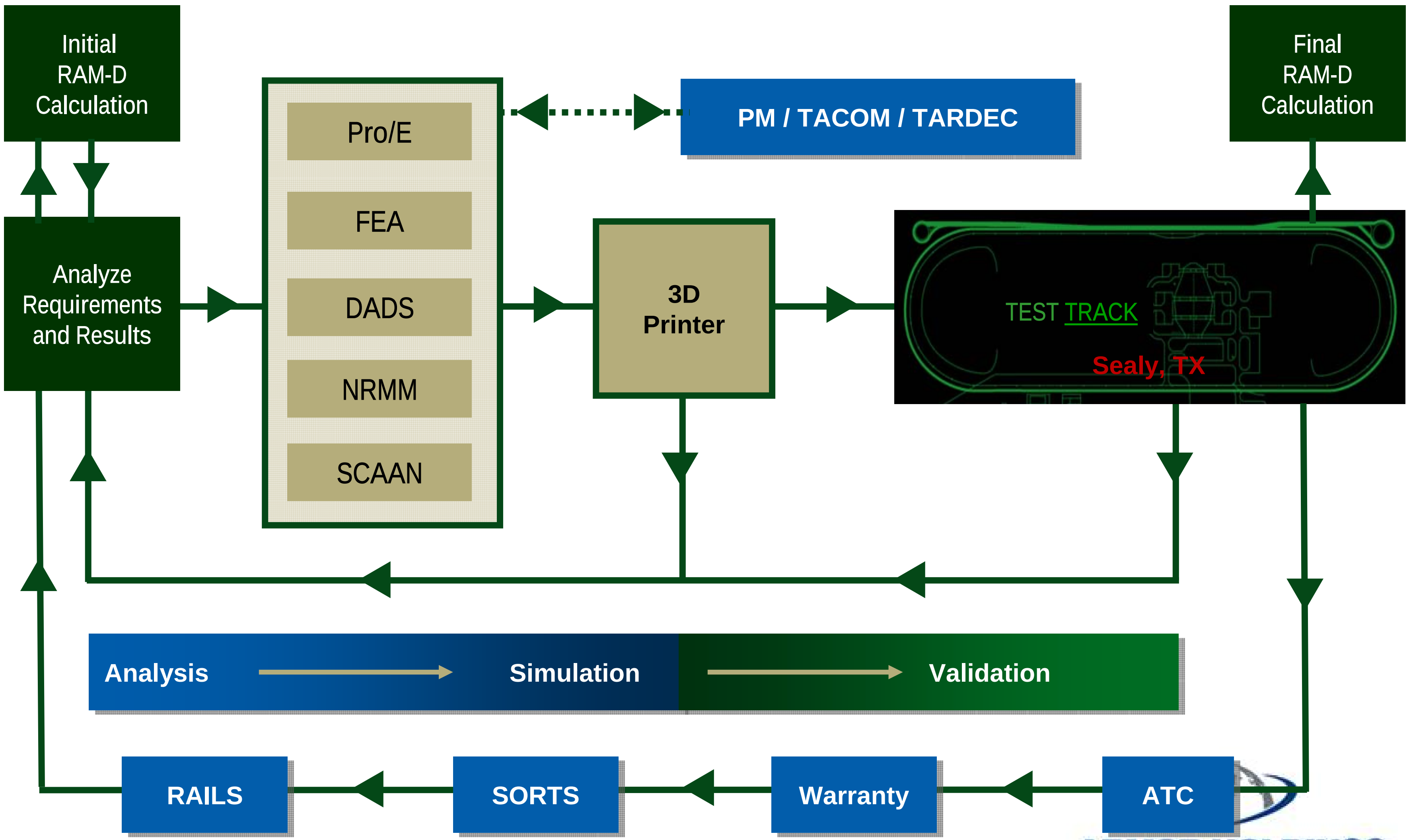
DARPA

SwRI

Testing in the Design Phase

Regis Luther

Measuring and Validating Reliability
Modeling/Simulation/Validation



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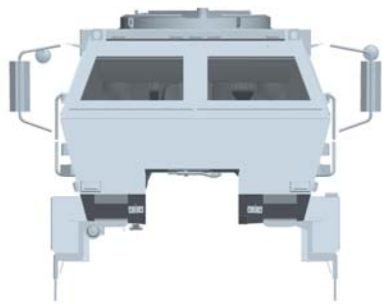
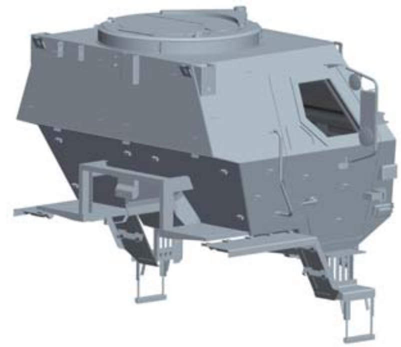
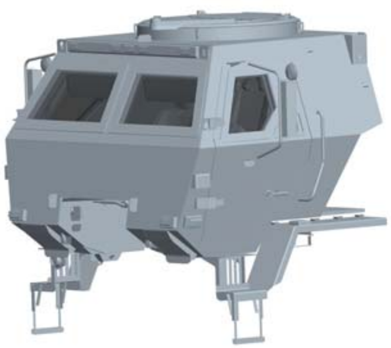
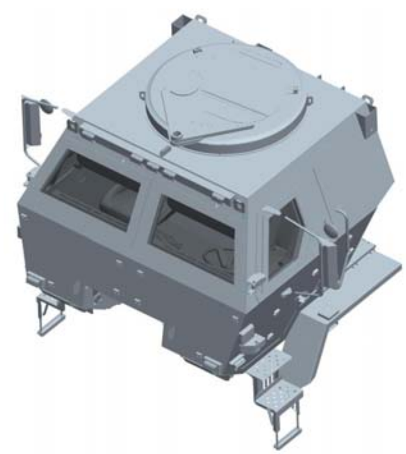
Model Based Definitions







S&S Blast Mine Test

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LSAC

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ARMOR HOLDINGS

- Founded in 1996 - Headquarters in Jacksonville, Florida
- Public Company (NYSE - AH)
  - Market Cap of $1.898 billion (as of 8/16/06)
- Revenue
  - 2004 Revenue - $980 million
  - 2005 Revenue - $1.637 billion
  - 2006 Revenue - $2.4 billion anticipated
- 6,200 Employees in Three Business Units

		2005 Revenue
-	Aerospace & Defense Group (ADG)	$1,189m
+	*Stewart & Stevenson, Pinzgauer*	*$ 726m*
-	Products Group	$ 309m
-	Centigon	$ 139m

- Manufacturing Operations
  - AL, AZ, CA, FL, KY, MA, MI, NH, OH, PA, TN, TX, WY
  - Brazil, Colombia, France, Germany, Mexico, United Kingdom, Venezuela, Switzerland

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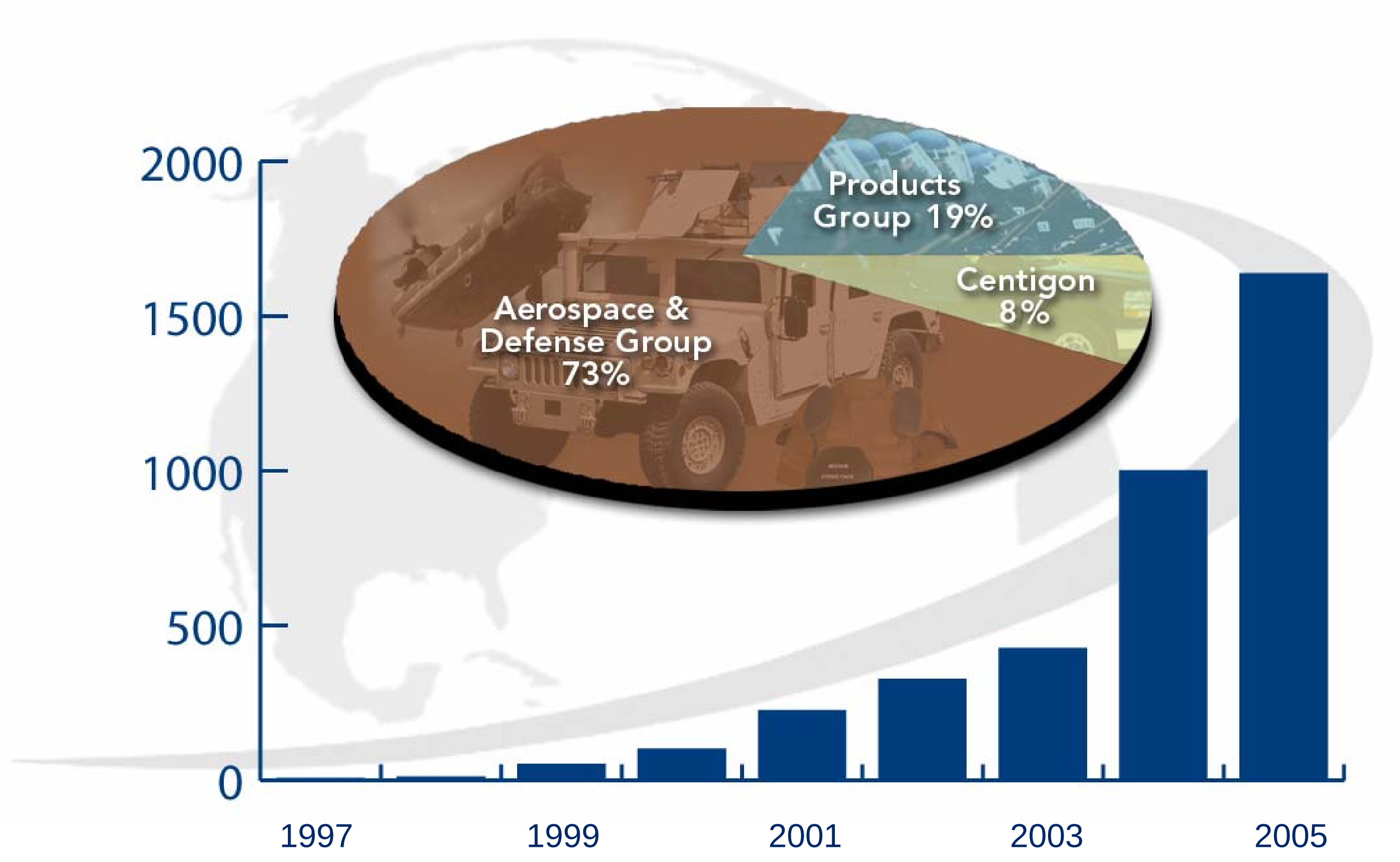
AH 2005 Revenue*



* Exclusive of 2005 Stewart & Stevenson and Pinzgauer revenue of $726 million

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AH Global Reach

★ Aerospace & Defense Group
★ Centigon (Mobile Security)
★ Products Group

Armor Holdings has sold product to all countries in blue

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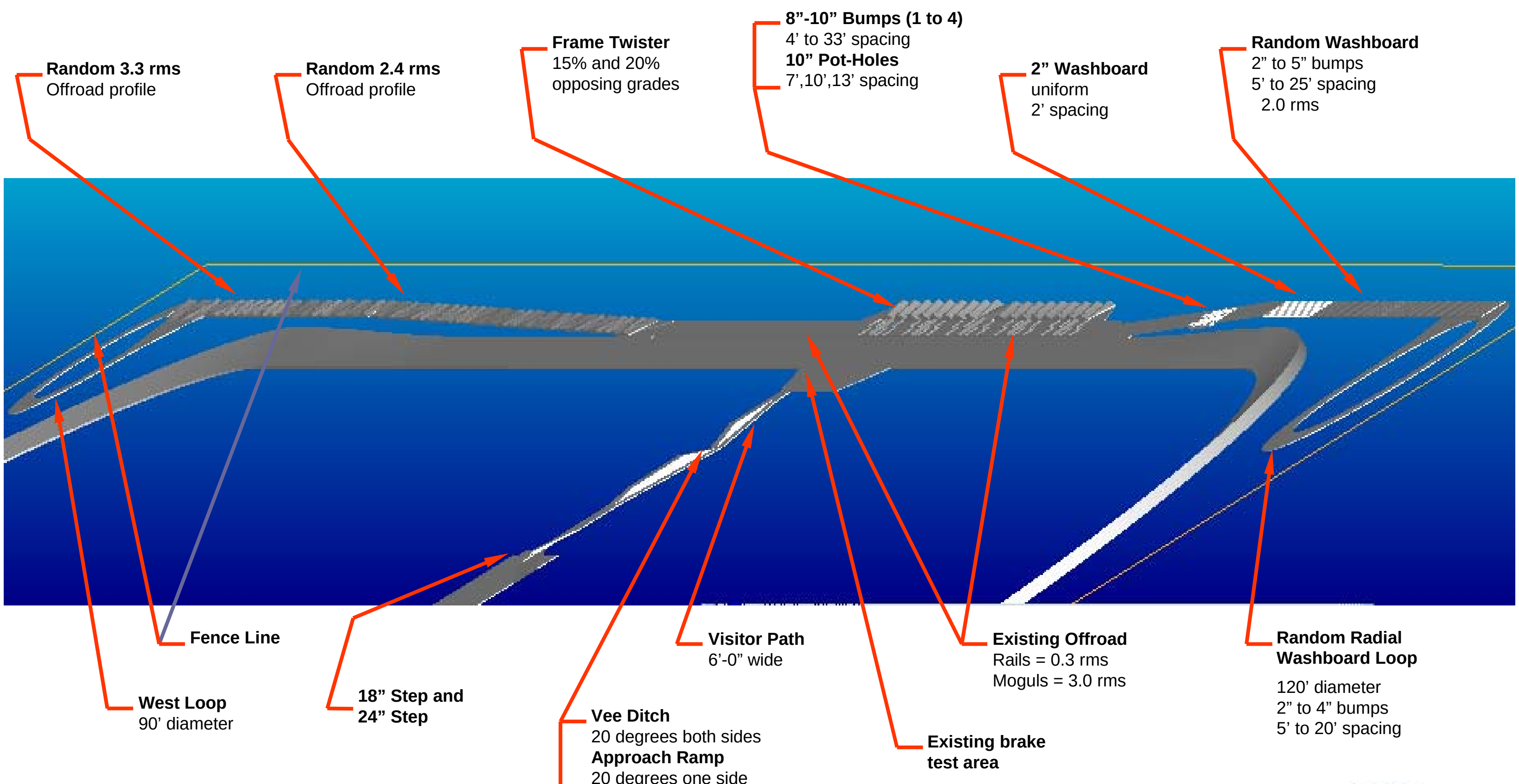
Test Capabilities

- Rolling road and test track facilities
- Complete vehicle testing
- Military Packaging
- Ballistics testing
- Materials testing
- Static testing
- Dynamic testing
- Full-scale impact testing
- Outdoor and indoor drop towers
- Horizontal sled
- High speed photography and video

US Military - FAA - Automotive - Commercial

In-house test capabilities for internal R&D; certified outside labs validate or qualify systems

Test Track



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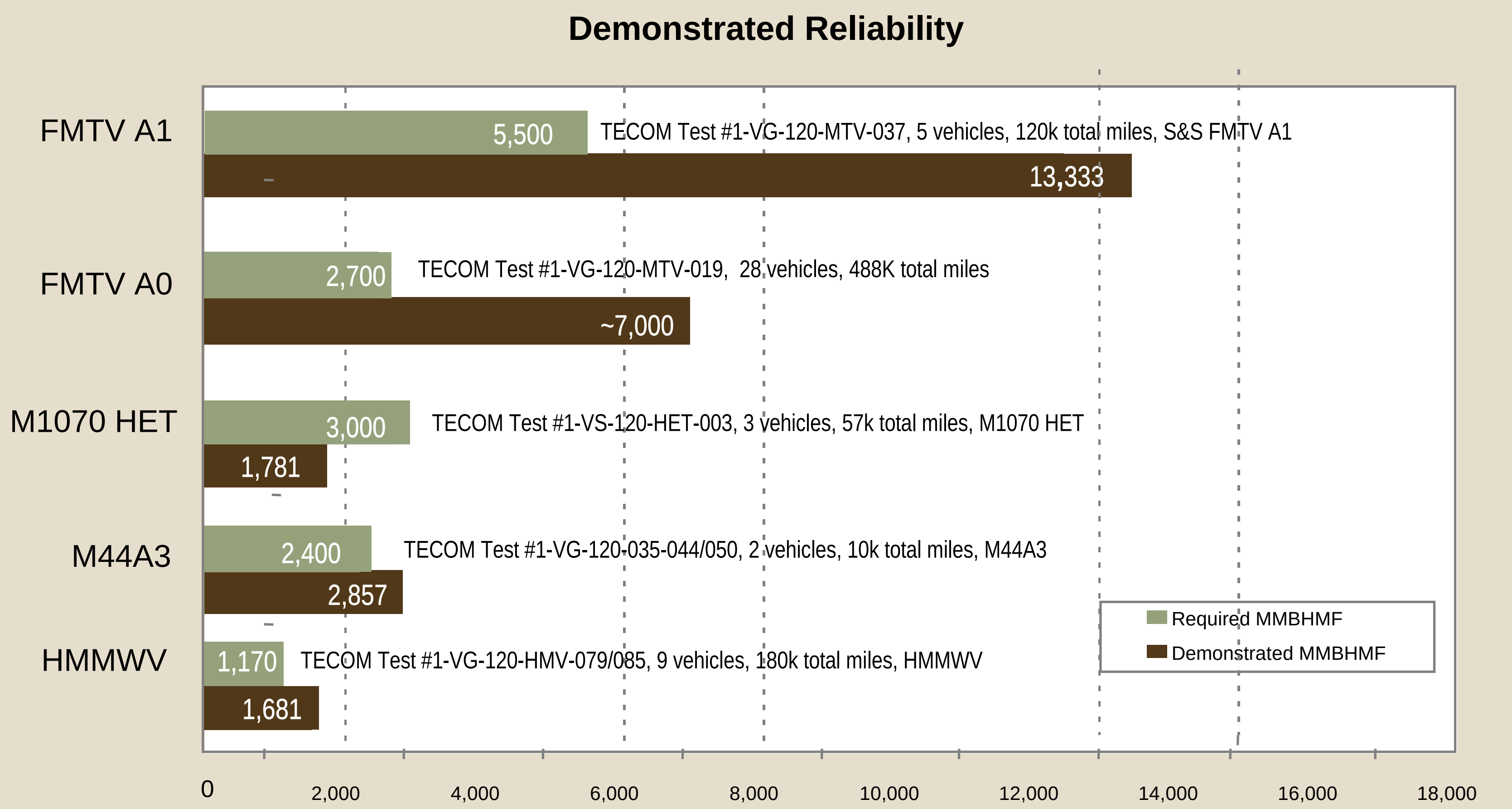
Ultra-Reliability



TECOM = Test and Evaluation Command

MMBHMF = Mean Miles Between Hardware Mission Failure

* Fleet average of test vehicles including all failures attributed to CR changes and A1 baseline.

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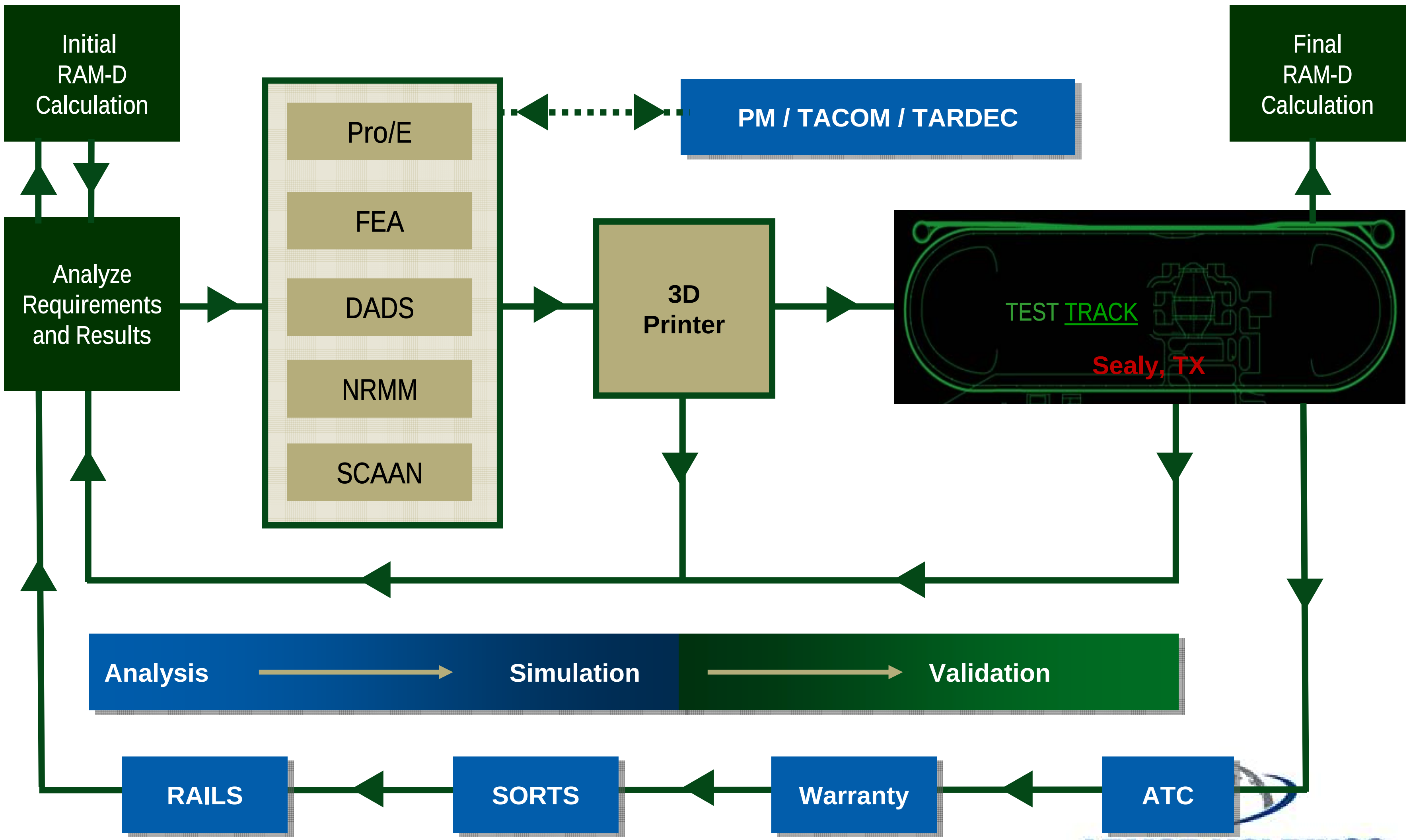
Measuring and Validating Reliability Modeling/Simulation/Validation



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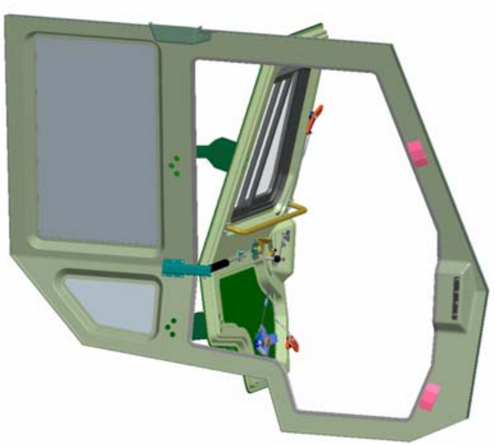
LTAS



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Questions

Raytheon

Customer Success Is Our Mission

Statistically-Based
Test Optimization Strategies

23rd Annual NDIA Test & Evaluation Conference
March 13, 2007

Neal Mackertich, Ph.D
Raytheon Integrated Defense Systems

Best Practices in Statistically-Based Test Optimization

Why, What , When & How: There are lots of meaningful testing questions and opportunities to explore…

The focus of this presentation is to share with you three industry cited best practices around the use of statistically - based test optimization strategies:

- Usage-based Statistical Testing
- Combinatorial Design Methods
- Critical Parameter Management

Raytheon

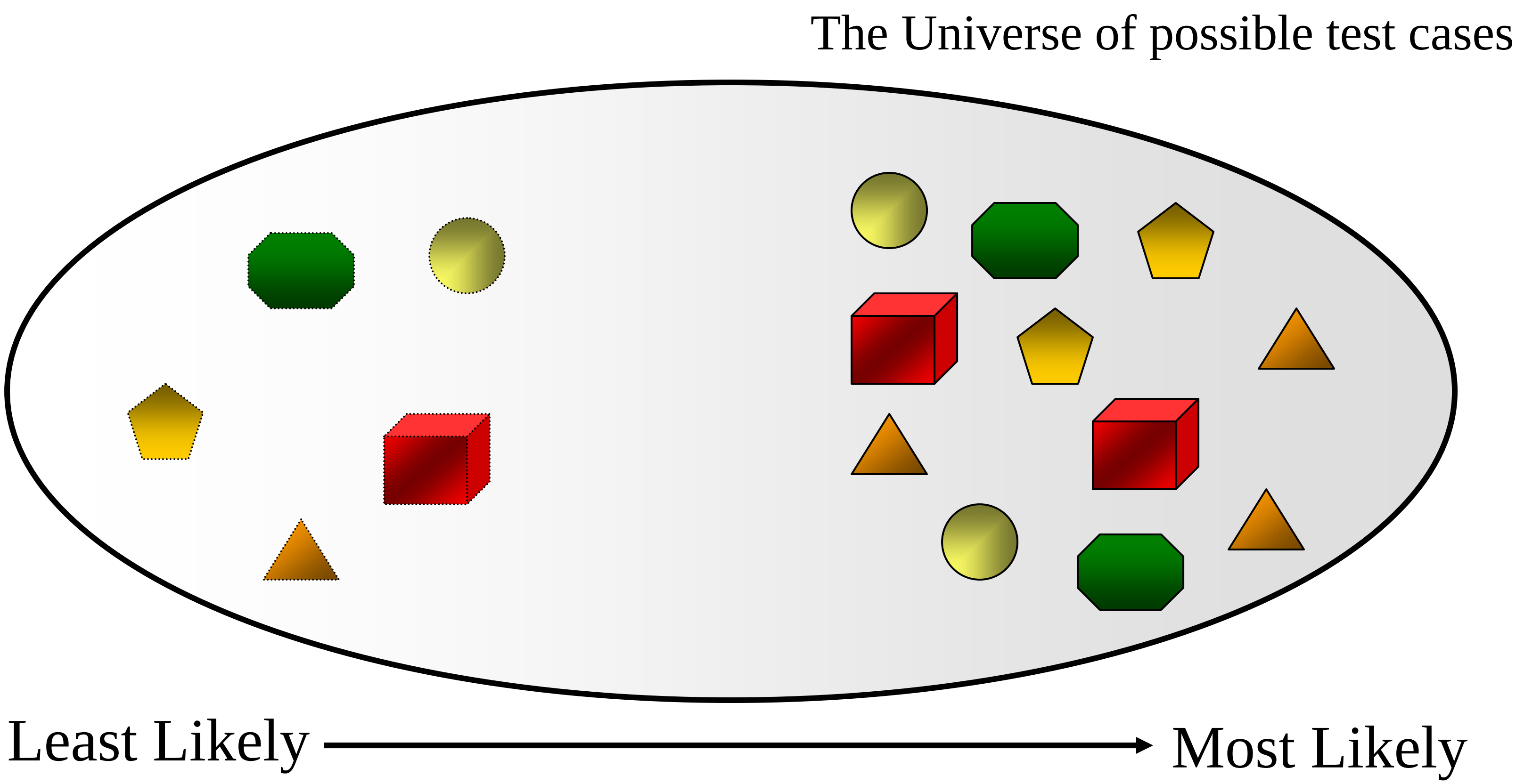
What to Test?

Okay, let's say we need to test a system or subsystem…

How do we typically determine what test cases to run?

Usage-Based Statistical Testing

- Use-Based Statistical testing emphasizes the operational scenarios most likely to occur

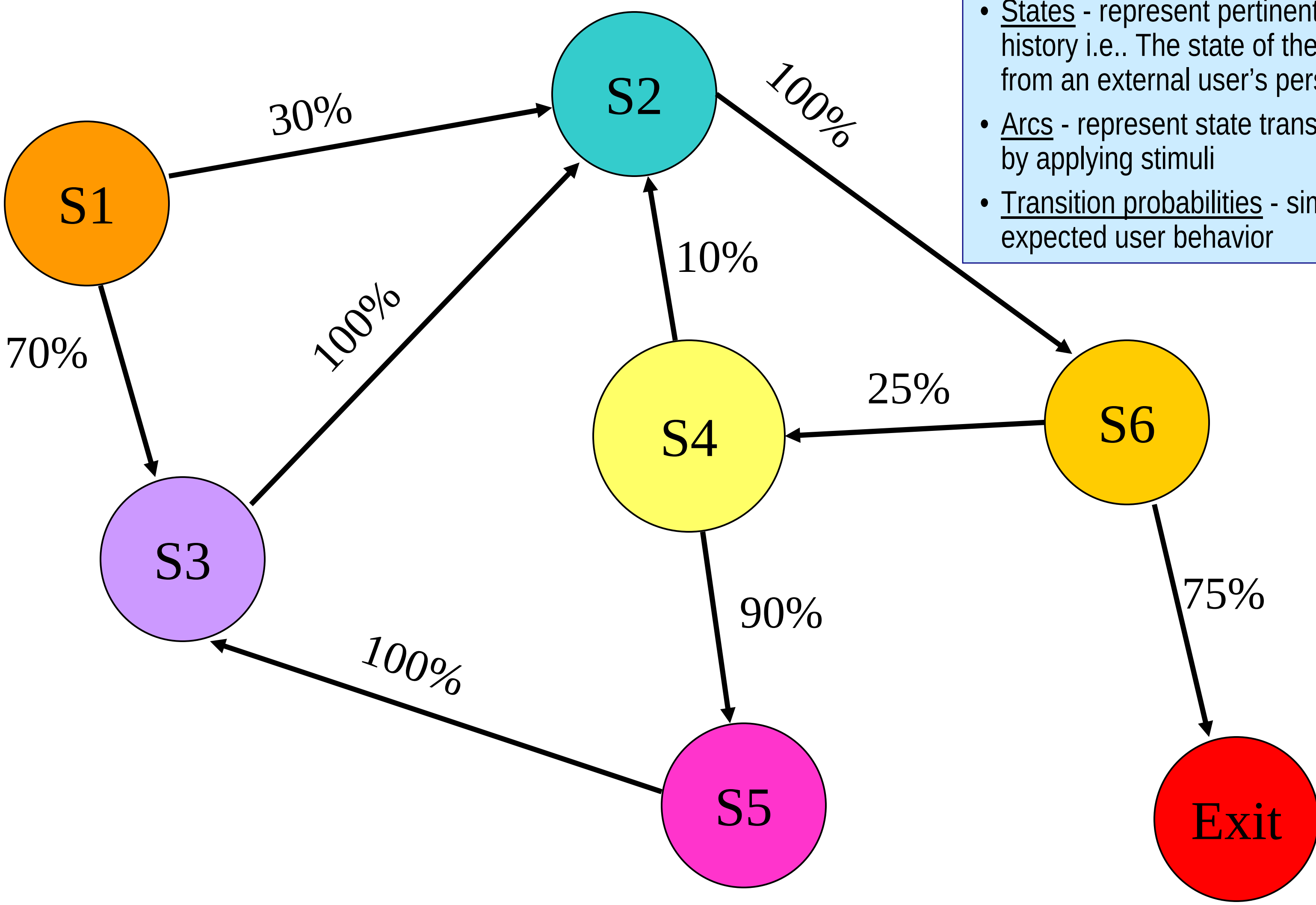


Raytheon

Usage-Based Statistical Testing

- Testing based on the way the system / product is to be operational used.
- A “Use Case” state diagram (in the form of a Markov Model) is used to generate a representative, random sample usage so statistical methods can be applied to model System behavior.
- Specific test case generation is accomplished using input stimuli selected via a random walk through the Markov chain.

Sample Usage Model



- States - represent pertinent usage history i.e.. The state of the software from an external user's perspective.
- Arcs - represent state transitions caused by applying stimuli
- Transition probabilities - simulate expected user behavior

Usage-Based Statistical Testing- Case Study Results

- Escaping defects were less than previous methods (1.16 defects per KSLOCs Vs. 6-defects/ KSLOCs) from previous testing method.
- Development costs met budgets.
- Major functions were integrated quickly.
- Poll was taken with the leads about whether to use this statistical testing on a follow-on program; results were <u>unanimous</u> to use statistical testing for next project which has already started!!

What are Combinatorial Design Methods?

- A testing methodology in which a subset of all possible combinations is chosen such that all N-way combinations are tested.

- Covering all 2 way combinations would require that for any two factors A and B, where Ai and Bi are valid levels for A and B, there is a test for all Ai and Bi combinations.

Why not DOE?

The use of proven statistical / combinatorial methods can be very helpful here…

But why not just use Design of Experiments (DOE) techniques?

CDM Advantages

- The use of N-way combinations provide reasonable, balanced coverage across the test space.
- More realistic than full/fractional designs
  - Compatible with constraints
  - Compatible with factors at different levels
  - Can account for previous test
- Drastically reduces the total number of test cases when compared to all combinations.
- Since generating test cases is very quick and simple, there are no major barriers to using CDM as part of the testing process.
- Can be used in almost all phases of testing.

Black-Box Testing Scenario

Definition	Black-box type testing geared to functional requirements of an application.
Example Application	Graphics manipulation function that converts from one format to another.
Inputs	Source Format (GIF, JPG, TIFF, PNG) Dest. Format (GIF, JPG, TIFF, PNG) Size (Small, Med, Large) # colors (4 bit, 8 bit, 16 bit, 24 bit) Destination (Local drive, network drive) Windows Version (95, 98, NT, 2000, Me)
Outputs	Correct conversion (True or False)
Constraints	If Destination Format is GIF, then # colors cannot be 16 bit or 24 bit.
All Combinations	1920 Test Cases
2 Way Combinations	22 Test Cases

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Regression Testing Scenario

Definition	Re-testing after fixes or modifications of the software or the environment in which the software operates.
Example Application	Graphics functionality on previous page must be expanded to support a new file format (WMF) and a new OS (Windows XP).
Inputs	Source Format (GIF, JPG, TIFF, PNG, WMF) Dest. Format (GIF, JPG, TIFF, PNG, WMF) Size (Small, Med, Large) # colors (4 bit, 8 bit, 16 bit, 24 bit) Destination (Local drive, network drive) Windows Version (95, 98, NT, 2000, Me, XP)
Outputs	Correct conversion (True or False)
Constraints	If Destination Format is GIF, then # colors cannot be 16 bit or 24 bit
All Combinations	1620 Test Cases
2 Way Combinations	32 Test Cases

CDM- Case Study Application

- Testing program requirements
  - Factory Acceptance Test (FAT) Dry Run
  - FAT
  - Site Acceptance Test (SAT) Dry Run
  - SAT

- Not realistic to do exhaustive testing of all 144 possible System test scenarios

- Quasi-Exhaustive strategy invented
  - 100% of tests for FAT Dry Run
  - 10% of tests, selected at random, for FAT
  - 50% of tests, selected at random, for SAT Dry Run
  - 10% of tests, selected at random, for SAT

CDM Case Study- A Comparison of Strategies

Quasi-Exhaustive Strategy	FAT Dry Run	FAT	SAT Dry Run	SAT
Number of test cases	144	15	72	15
Time spent writing test procedures	49.00 hours	0.00 hours	8.00 hours	0.00 hours
Time spent performing data paths test procedures	73.25 hours	8.75 hours	55.00 hours	12.25 hours
Number of persons involved in testing	1	3	3	4
Total Labor Hours	370.5 hours (46.3 days)			

CDM Strategy	FAT Dry Run	FAT	SAT Dry Run	SAT
Number of test cases	12	12	12	12
Time spent writing test procedures	16.00 hours	0.00 hours	3.00 hours	0.00 hours
Time spent performing data paths test procedures	7.25 hours	7.25 hours	10.00 hours	10.00 hours
Number of persons involved in testing	1	3	3	4
Total Labor Hours	118.0 hours (14.8 days)			

Bottom Line Comparison (Time-to-Market Savings)

- CDM Strategy was superior to Quasi-Exhaustive Strategy
  - Schedule savings = 68%
  - Cost savings (labor) = 67%

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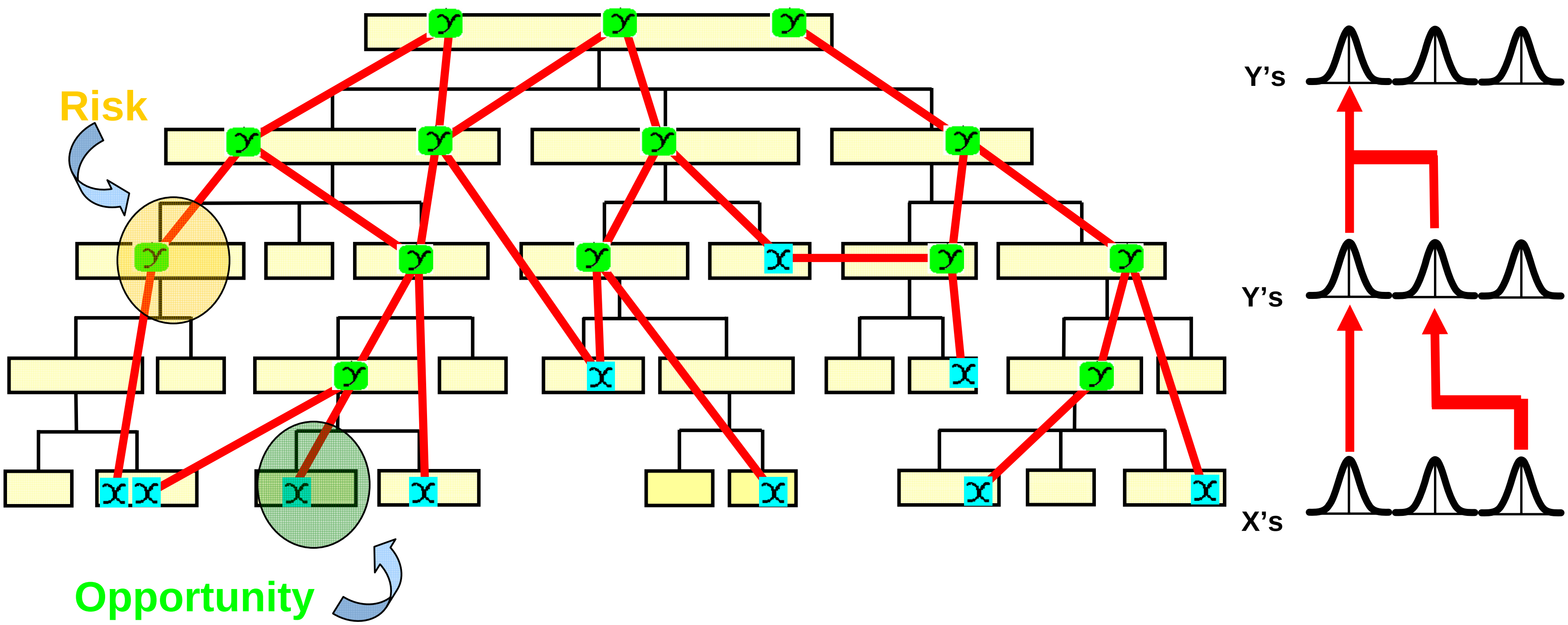
What is Critical Parameter Management?

- A disciplined methodology for managing, analyzing, and reporting technical product performance.
- A process for mathematically linking system parameters for sensitivity analysis and optimization of critical performance threads.
- A strategic tool for improving product development by unifying and integrating systems, design, manufacturing and test activities.

CPM = TPMs + Other parameters critical to functionality, cost, schedule or customer

Performance Analysis

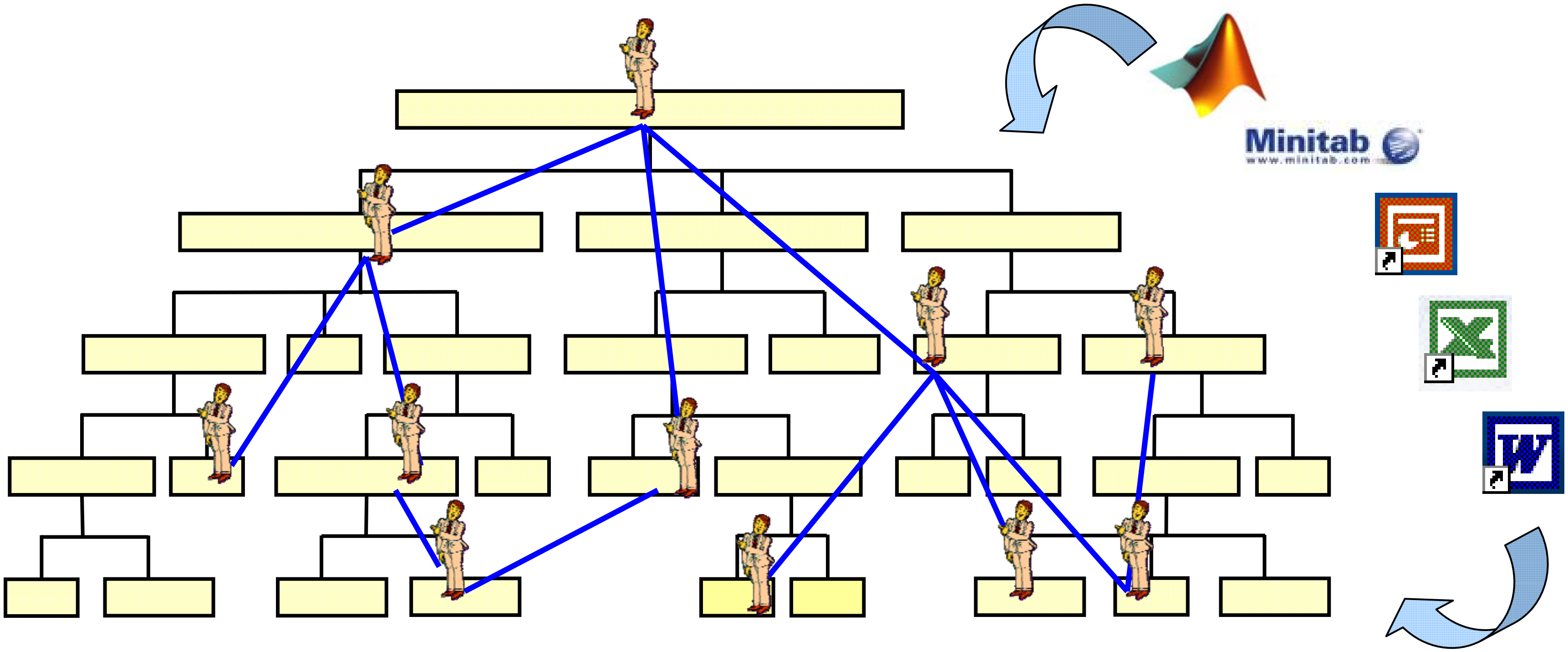
"The System Can…."



CPM Statistically Flow-Up Design, Supplier and Manufacturing Capabilities Exposing Performance Risks and Opportunities

Whitepaper Management and Task Delegation

Engineering Documents and Whitepaper Analyses



Attach Engineering Documents, Models, and Whitepaper Analysis.

Connect people to analyses, requirements, and performance measures.

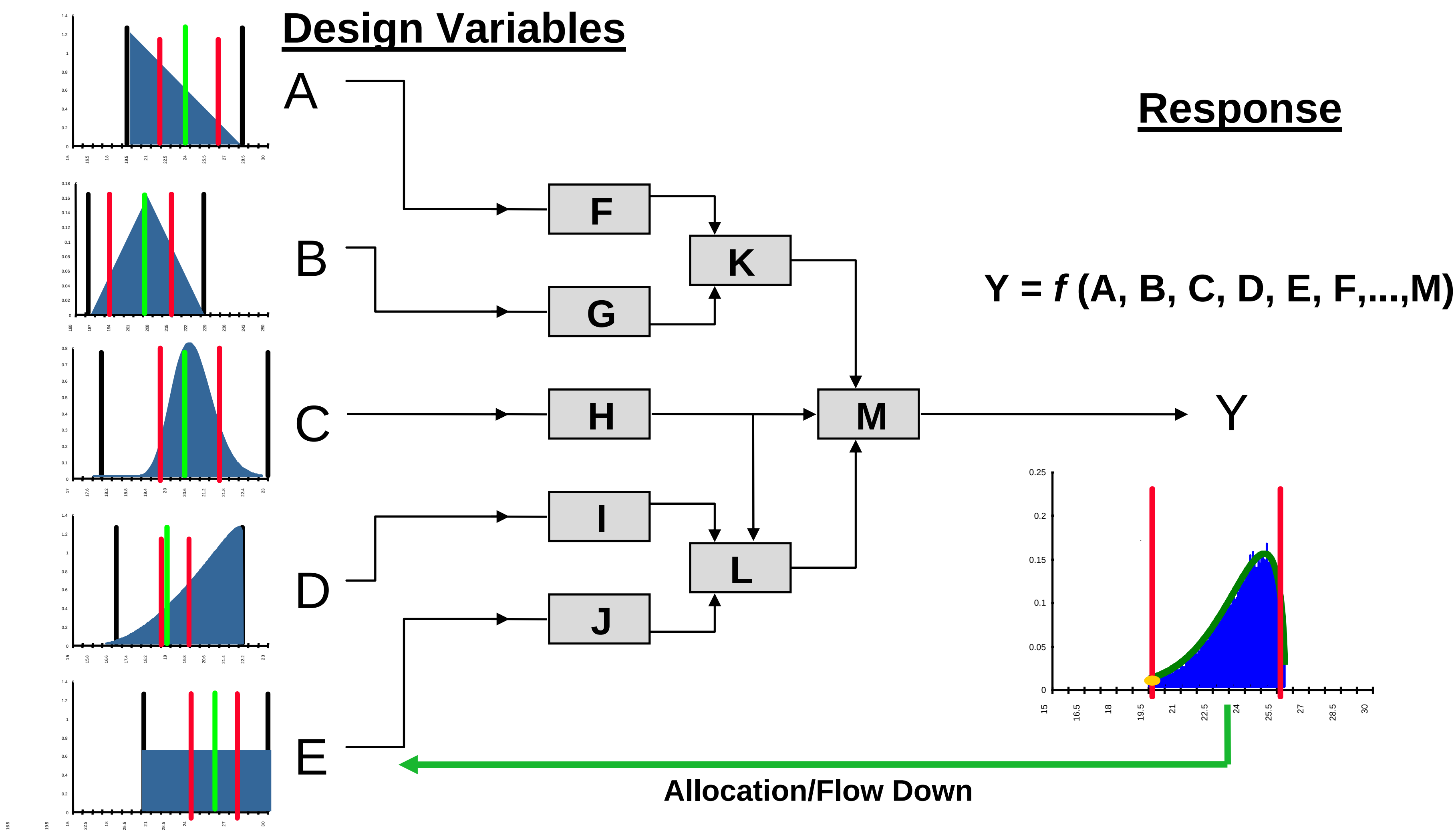
CPM Program Benefits

- Facilitate Analysis
  - Statistical modeling & optimization of the performance – cost trade space
  - Real-time System-level sensitivity analysis
  - Connects analyses between system, subsystem and component levels

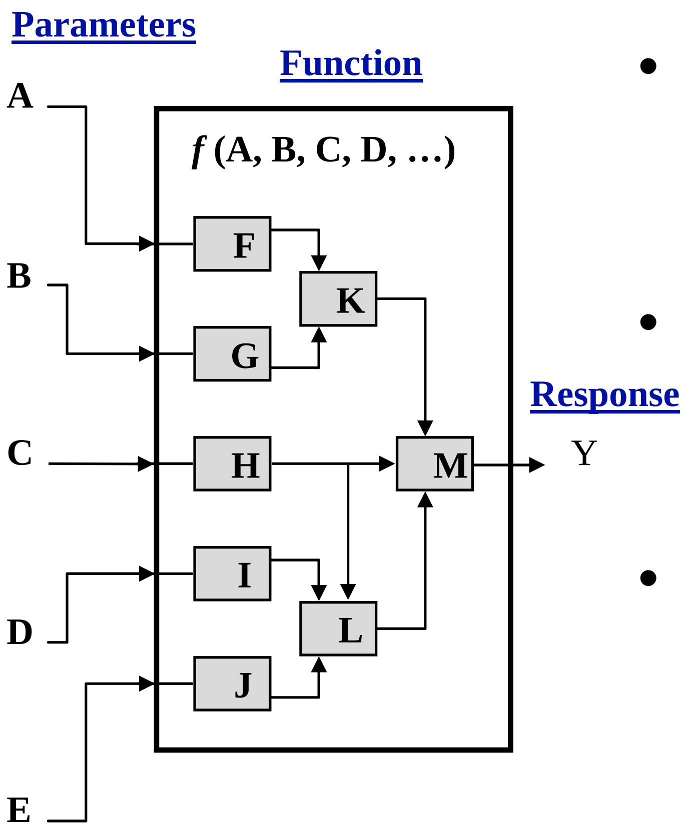
- Improve Collaboration
  - Shares technical analysis and knowledge
  - Links ownership to parameters
  - Mathematically connects Program teams and parameters to understand requirement flow-down
  - Captures and leverages invested intellectual capital for future business reuse

- Enable TPM Management and Reporting
  - TPM design margins are statistically tracked over product lifecycle
  - Automated, real-time TPM data gathering / report generation
  - Reconciliation of requirement allocation and engineering design capability

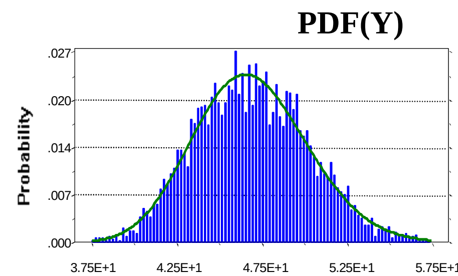
DFSS Statistical Performance Analysis

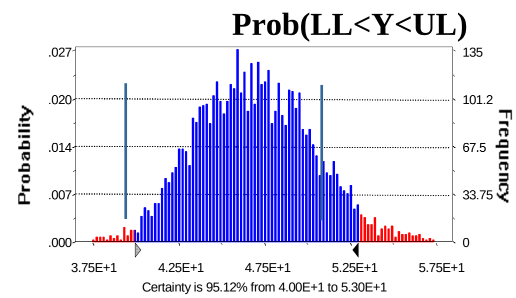


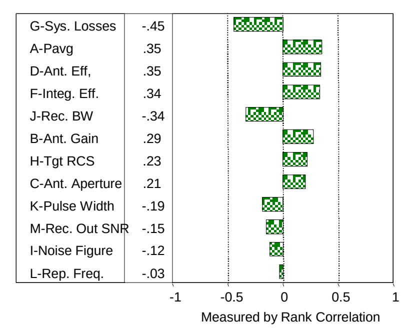
Statistical Performance Analysis Results In…



- **A prediction of the Response Statistical Properties**
- **A prediction of the Probability of Non-Compliance**
- **An assessment of the Contribution of Parameter Variation to Response Performance and Cost**







Results from Crystal Ball® Monte Carlo SW

Traditional TPM Stoplight Reporting

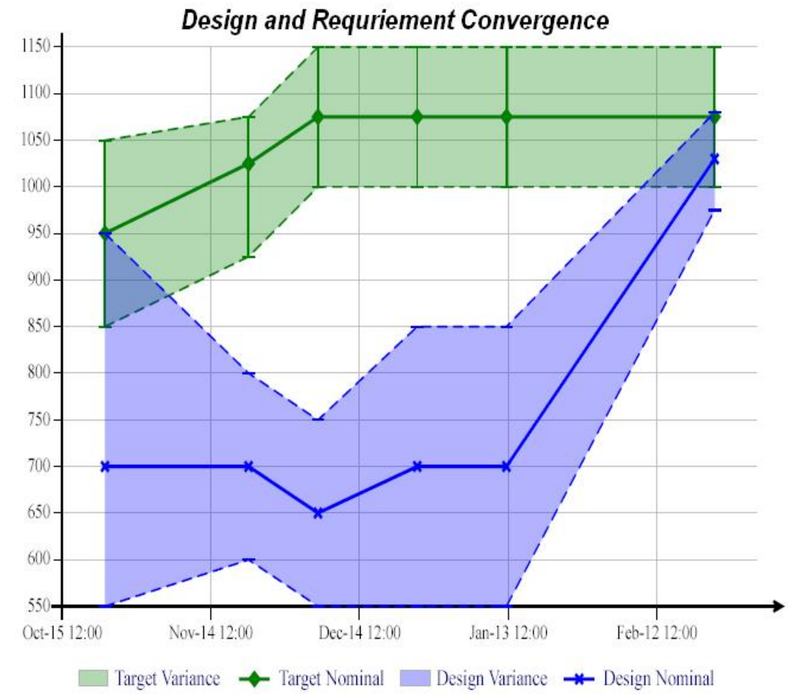
TPM Number	Description	Aug '05	Sep '05	Oct '05	Nov '05	Dec '05	CDR Jan '06
TPM-001	Single Pulse Sensitivity	G	G	G	G	G	G
TPM-002	Search Sensitivity	G	G	G	G	G	G
TPM-003	Range Accuracy	G	G	G	G	G	G
TPM-004	Angle Accuracy	G	G	G	G	G	G
TPM-005	RCS Accuracy	G	G	G	G	G	G
TPM-006	Phase Stability	Y	Y	Y	Y	Y	G
TPM-007	Polarization Isolation	G	G	G	G	G	G
TPM-008	Ellipticity	Y	Y	Y	Y	Y	G
TPM-009	Range Sidelobe Level	G	G	G	G	G	G
TPM-010	Range Resolution	G	G	G	G	G	G
TPM-011	2-Way Notch Depth (combined)	Y	G	G	G	G	G
TPM-012	Receive Pattern Sidelobe Level	Y	G	G	G	G	G
TPM-013	Weight	G	G	G	G	G	G

G	Meets Requirement with Margin
Y	Meets Requirement with No Margin
R	Does Not Meet Requirement

Previous TPM Reporting / Tracking method is vague and ambiguous with respect to the design margin for each metric. TPM report was only tracked and managed on a monthly basis for the tracking book.

Statistically-Based TPM Reporting / Management

- Statistically track design capability and requirement by establishing upper and lower limits
- Monitor design capability and requirement convergence over product lifecycle:
  - IPDR, PDR, CDR etc.
  - Design, Manufacturing, Integration, Test

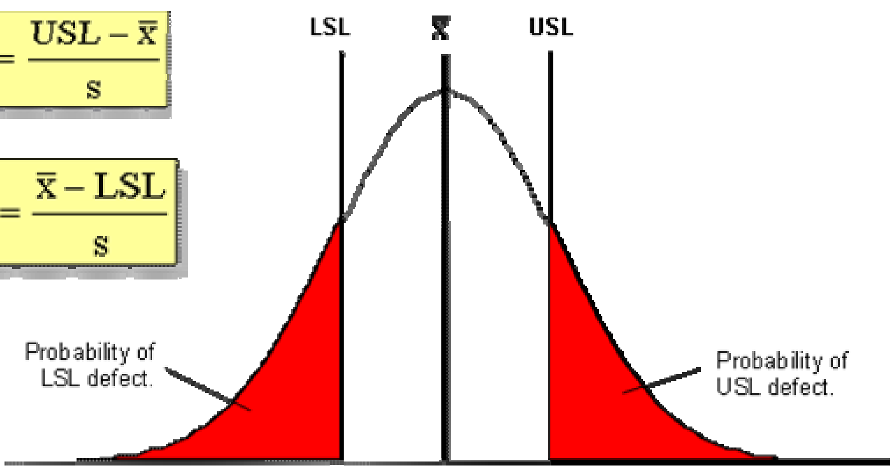


Probability of Non-Compliance

$$PNC = PNC(Z_{USL}) + PNC(Z_{LSL})$$

$$Z_{USL} = \frac{USL - \bar{x}}{s}$$

$$Z_{LSL} = \frac{\bar{x} - LSL}{s}$$



Cp and Cpk

$$Cpk = \min\left(\frac{USL - \bar{x}}{3 * s}, \frac{LSL - \bar{x}}{3 * s}\right)$$

$$Cp = \frac{USL - LSL}{6s}$$

New Automated TPM Reporting Format

TPM design margins are statistically tracked real-time

Block Name: TPMs | **BOM ID#:** | 2/9/2006

	CFR (Y)	Spec Code	Owner		Units	Target Value: Lower Limit	Target Value: Nominal	Target Value: Upper Limit	Design Model Prediction: Nominal	Design Model Prediction: Mean	Design Model Prediction: Std. Dev.	Design Model Prediction: Cp	Design Model Prediction: Cpk	Validation Test Data: Mean	Validation Test Data: Std. Dev.	Validation Test Data: Cp	Validation Test Data: Cpk
	TPM 1	R				0.9400	0.9600	0.9990	0.9672	1.9040	0.6238	0.0158	-0.9836	0.0000			
	TPM 2	R				6.0000	8.0000	11.0000	7.0000	9.5000	0.5833	1.4286	0.3571	0.0000			
	TPM 3	Y				43.0000	45.0000	49.0000	43.0000	42.7500	0.3750	2.6667	-0.7222	0.0000			
	TPM 4	G				14.0000	17.0000	19.0000	16.0000	16.5000	0.4167	2.0000	1.5000	0.0000			
	TPM 5	G				0.1000	0.1200	0.1600	0.1250	0.1250	0.0008	12.0000	9.5000	0.0000			
	TPM 6	R				4.0000	6.8000	8.0000	7.0000	7.0000	0.0833	8.0000	3.5000	0.0000			
	TPM 7	Y				0.4000	1.0000	1.2000	0.6000	0.7000	0.0333	4.0000	2.8333	0.0000			
	TPM 8	G				0.4000	0.4500	0.5000	0.4500	0.4550	0.0042	4.0000	3.4333	0.0000			

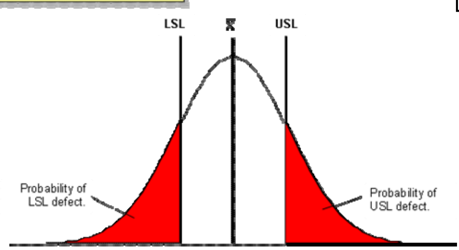
Meaningful stoplights based on statistical sensitivity

Compares requirement allocation vs. current design capability

Includes sensitivity and statistical information

Captures complete product lifecycle: requirements, design, manufacturing, testing, validation, etc. (other columns not shown)

$PNC = PNC(Z_{USL}) + PNC(Z_{LSL})$



Using Technology Readiness Assessments (TRAs) to Assess the Maturity of Life-Cycle Related Technologies

National Defense Industrial Association
23rd Annual National Test & Evaluation Conference
March 12-15, 2007

Dr. Jay Mandelbaum

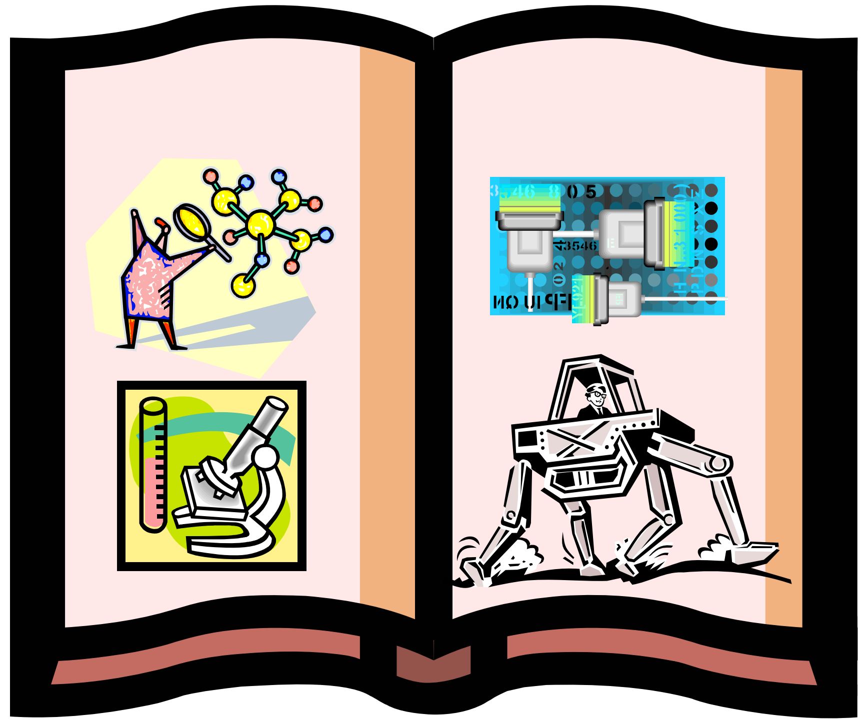
Institute for Defense Analyses
4850 Mark Center Drive • Alexandria, Virginia 22311-1882

Outline

- **Introduction to Technology Readiness Assessments (TRAs)**
- **Life-cycle-related (LCR) Critical Technology Element (CTE) identification**
- **Life-cycle-related Critical Technology Element assessment**
- **References and resources**

What is a TRA?

- **Systematic, metrics-based process that assesses the maturity of Critical Technology Elements (CTEs)**
  - **Uses Technology Readiness Levels (TRLs) as the metric**
- **Regulatory information requirement for *all* acquisition programs**
  - **Submitted to DUSD(S&T) for ACAT ID and IAM programs**



≠ Not a risk assessment

≠ Not a design review

≠ Does not address system integration

Critical Technology Element (CTE) Defined

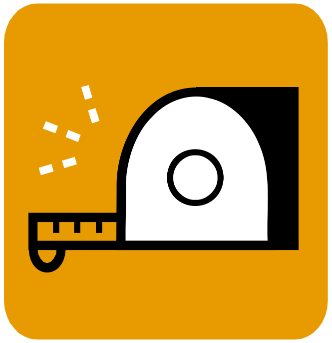
A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements with acceptable development cost and schedule and with acceptable production and operation costs *and* if the technology element or its application is either new or novel.

Said another way, an element that is new or novel or being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition or its operational utility.

CTEs may be hardware, software, manufacturing, or life cycle related at the subsystem or component level

TRL Overview

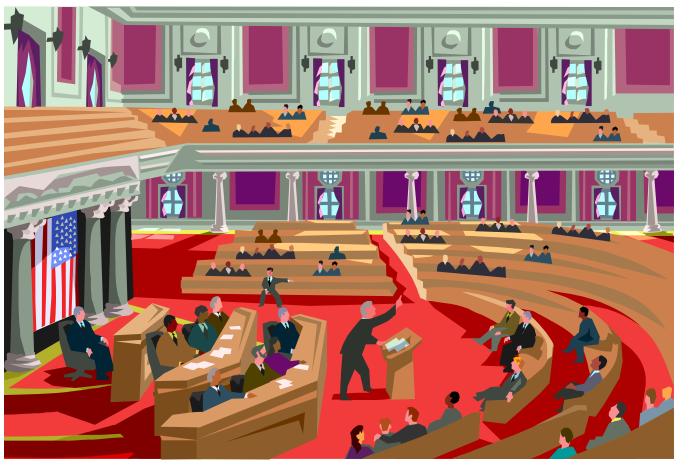
- **Measures technology maturity**
- **Indicates what has been accomplished in the development of a technology**
  - **Theory, laboratory, field**
  - **Relevant environment, operational environment**
  - **Subscale, full scale**
  - **Breadboard, brassboard, prototype**
  - **Reduced performance, full performance**



- **Does not indicate that the technology is right for the job or that application of the technology will result in successful development of the system**

Why is a TRA Important? (1 of 2)

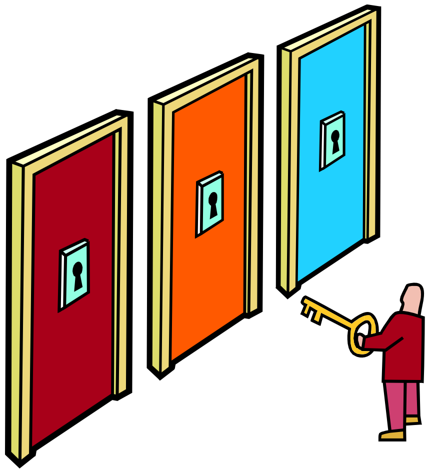
- **The Milestone Decision Authority (MDA) uses the information to support a decision to initiate a program**
  - **Trying to apply immature technologies has led to technical, schedule, and cost problems during systems acquisition**
  - **TRA established as a control to ensure that critical technologies are mature, based on what has been accomplished**



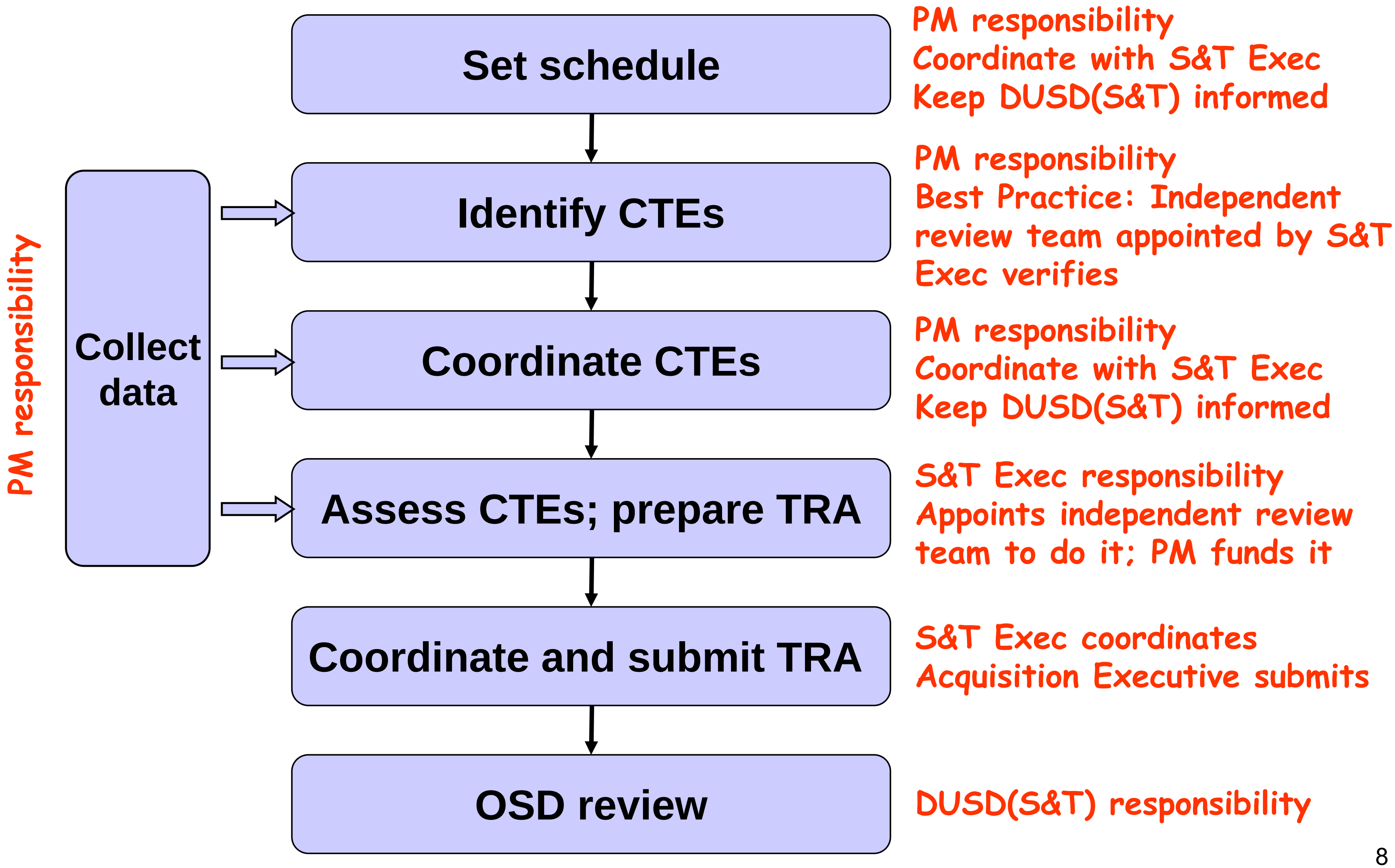
- **Congressional interest**
  - **MDA must certify to Congress that the technology in programs has been demonstrated in a relevant environment at program initiation**
  - **MDA must justify any waivers for national security to Congress**

Why is a TRA Important? (2 of 2)

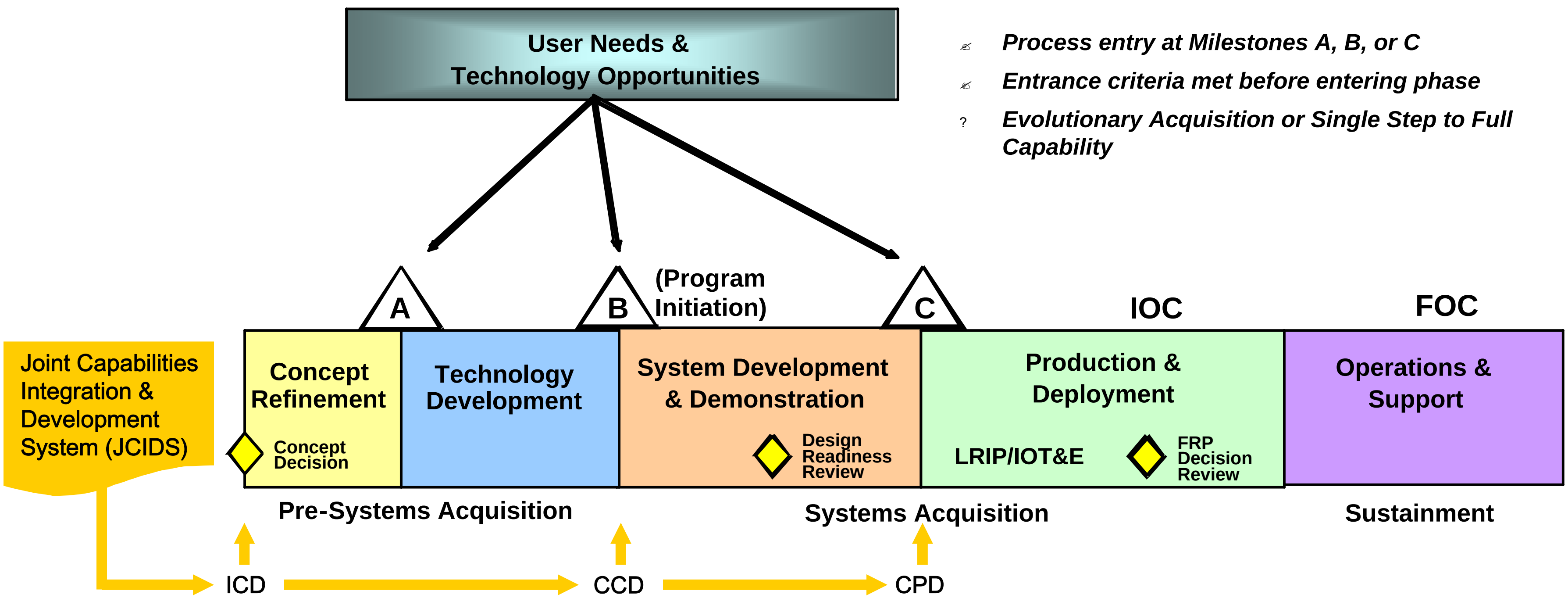
- **The PM uses the expertise of the assessment team and the rigor and discipline of the process to allow for:**
  - **Early, in depth review of the conceptual product baseline**
  - **Periodic in-depth reviews of maturation events documented as verification criteria in an associated CTE maturation plan**
  - **Highlighting *(and in some cases discovering)* critical technologies and other potential technology risk areas that require management attention (and possibly additional resources)**
- **The PM, PEO, and CAE use the results of the assessment to:**
  - **Optimize the acquisition strategy and thereby increase the probability of a successful outcome**
  - **Determine capabilities to be developed in the next increment**
  - **Focus technology investment**



Process Overview



Overview of Technology Considerations During Systems Acquisition



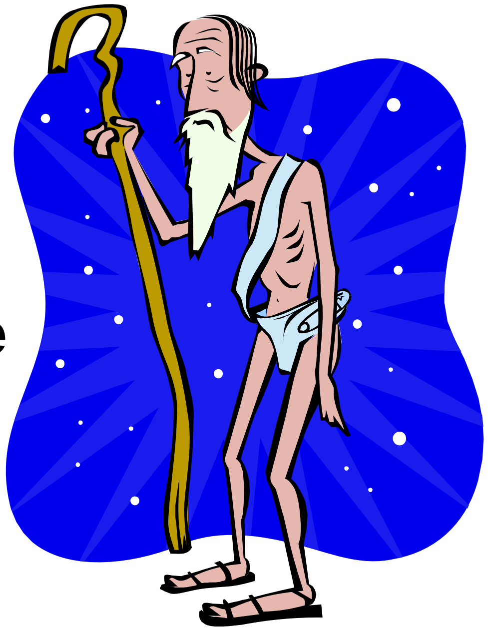
TRAs required at MS B, MS C, and program initiation for ships (usually MS A).

Outline

- Introduction to Technology Readiness Assessments (TRAs)
- Life-cycle-related (LCR) Critical Technology Element (CTE) identification
- Life-cycle-related Critical Technology Element assessment
- References and resources

What is a Life-Cycle-Related CTE

- **LCR technologies impact system supportability cost and/or time. They may:**
  - **Reduce the logistics footprint**
  - **Improve reliability/maintainability**
  - **Lower operating, support, or maintenance manpower requirements**
  - **Enhance training**
  - **Enhance human factors interactions**
  - **Increase operational availability or readiness**
  - **Improve the upgradability of the system**



Examples of Life-Cycle-Related CTEs

- Corrosion resistant material
- Thermal protection materials
- Supportable low-observable materials
- Obsolescence mitigation technologies
- Technical data automation technologies
- Material handling technologies
- Simulators or training simulations
- Autonomic logistics sensors, data links, or messaging transmission
- Advanced technologies that affect human factors
- Analysis technologies, such as automated diagnostics and prognostics
- Methods/algorithms for sensing or trend analysis
- Technologies that enable open systems architecture

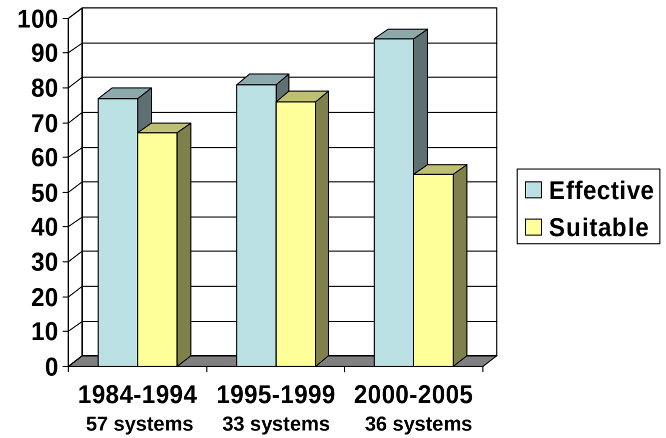
Why Be Concerned About Life-Cycle-Related CTEs (1 of 2)

- **Definitional perspective**
  - **All costs encompassed in CTE definition**
- **Policy perspective**
  - **DoDI 5000.2 states that "The project shall exit Technology Development when an *affordable increment* of militarily-useful capability has been identified …"**
  - **CJCSI 3170.01E defines *increment* as "a militarily useful and *supportable* operational capability that can be effectively developed, produced or acquired, deployed, and sustained…"**
  - **Mobility and logistics footprint are military capabilities and reliability and maintainability are military performance parameters**

Why Be Concerned About Life-Cycle-Related CTEs (2 of 2)

- **Experiential perspective**
  - **Increasing operating and support cost is decreasing acquisition capability; therefore greater emphasis is being placed on life cycle related issues including the technologies that affect them**
  - **Operating and support costs will continue to increase, thereby making life cycle related technologies even more critical**

Percentage of Systems Passing Operational Test



Source: 15 September 2005 David Duma presentation to the Defense Acquisition Performance assessment Project

Enhancing the CTE Identification Process to Better Detect Life Cycle Related Technologies (1 of 3)

- **Modify determination of criticality**
  - **Does the technology directly impact an operational requirement?**
  - **Does the technology have a significant impact on an improved delivery schedule?**
  - **Does the technology have a significant impact on the *life cycle* affordability of the system?**

A CTE may be critical from either a performance or a life cycle related perspective (or both)

Enhancing the CTE Identification Process to Better Detect Life Cycle Related Technologies (2 of 3)

- **Clarifying life cycle cost questions – procurement cost component**
  - How much does it cost to buy the component or subsystem with this technology?
  - Will the cost be significantly higher without the technology?

Enhancing the CTE Identification Process to Better Detect Life Cycle Related Technologies (3 of 3)

- **Clarifying life cycle cost questions – O&S cost component**
  - Does the technology significantly reduce the logistics footprint?
  - Does the technology significantly improve reliability/maintainability?
  - Does the technology significantly lower operational, support, or maintenance manpower requirements?
  - Does the technology significantly enhance training by some combination of lowering the resources needed or boosting its effectiveness?
  - Does the technology significantly increase operational availability or readiness?
  - Does the technology significantly improve the upgradability of the system?

Best Practices for Life-Cycle-Related CTE Identification

- **Independent panel should evaluate "significance" as used in the questions for identifying CTEs**
- **Include experts on appropriate LCR areas on the independent TRA panel**
- **Once a CTE has been identified from a performance perspective, also evaluate if it is an LCR CTE as well**
  - **Must also apply "new or novel test**

An Example of a Technology Being Critical From Two Perspectives

The AN/APG-79 Active Electronic Scanned Array (AESA) Radar

- **The technology directly impacts an operational requirement**
  - **The radar beam can be steered close to the speed of light, thereby enabling superior performance including air-to-air tracking at very long detection ranges, almost simultaneous air-to-air and air-to-surface mode capability, and enhanced situational awareness**
- **The technology significantly impacts life cycle affordability**
  - **MTBCF is greater than 15,000 hours for the array and greater than 1,250 hours for the entire system**
- **Everything in the system is new**

Sources: ***June 28, 2005 Raytheon News Release, Raytheon's Revolutionary APG-79 AESA Radar is Awarded a $580 Million Multi-Year Procurement Contract by the Boeing Company http://www.prnewswire.com/cgi-bin/micro_stories.pl?ACCT=149999&TICK=RTN&STORY=/www/story/06-28-2005/0003985043&EDATE=Jun+28,+2005; November 20, 2002 Raytheon News Release, Raytheon Demonstrates First Next-Generation AESA Capability at APG-79 Event http://www.raytheon.com/newsroom/briefs/112002.htm; Raytheon AN/APG-79 AESA data sheet http://www.raytheon.com/products/stellent/groups/sas/documents/legacy_site/cms01_050831.pdf.***

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Hardware and Manufacturing TRLs

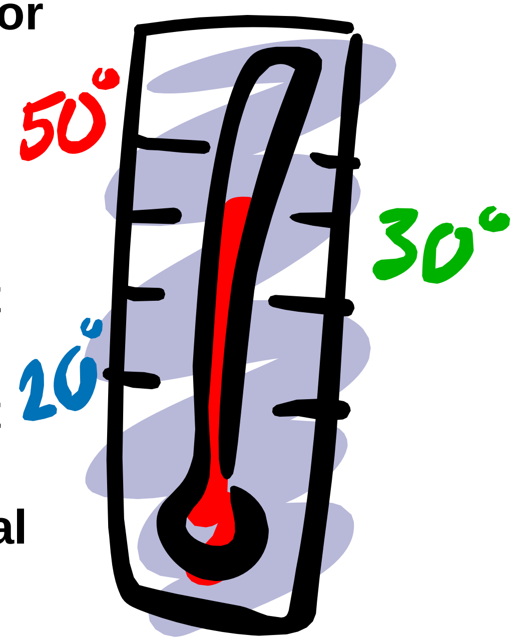
Increasing maturity

1. **Basic principles observed and reported**
2. **Technology concept and/or application formulated**
3. **Analytical and experimental critical function and/or characteristic proof of concept**
4. **Component and/or breadboard validation in a laboratory environment**
5. **Component and/or breadboard validation in a relevant environment**
6. **System/subsystem model or prototype demonstration in a relevant environment**
7. **System prototype demonstration in an operational environment**
8. **Actual system completed and qualified through test and demonstration**
9. **Actual system proven through successful mission operations**

Software TRLs

Increasing maturity

1. Basic principles observed and reported.
2. Technology concept and/or application formulated.
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Module and/or subsystem validation in a laboratory environment, i.e. software prototype development environment
5. Module and/or subsystem validation in a relevant environment
6. Module and/or subsystem validation in a relevant end-to-end environment
7. System prototype demonstration in an operational high fidelity environment
8. Actual system completed and mission qualified through test and demonstration in an operational environment
9. Actual system proven through successful mission proven operational capabilities



Assessments Supported by Additional Information Example: TRL 6 Hardware Criteria

- **Definition:** System/subsystem model or prototype demonstration in a relevant environment.
- **Description:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.

- **Supporting Information:** Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?

Modifying the CTE Assessment Process for Life-Cycle-Related Technologies (1 of 5)

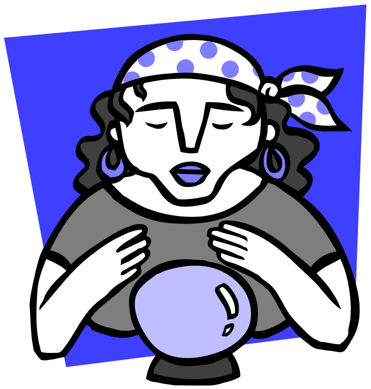
- The definitions and descriptions corresponding to the various TRLs apply to LCR technologies
- Supporting information sufficient when:
  - Long-term effects do not have to be calculated
    - TRL 3 (analytical and experimental critical function and/or characteristic proof of concept) or lower
  - Long-term effects of the LCR CTE can be calculated analytically and the risk of error is minimal

LAB PROTOTYPE SWL

    - Shipboard weapons loader (SWL) provides a capability for a single operator to upload and download munitions while reducing operator workload and life-cycle cost
    - SWL demonstrations can confirm ship manpower reductions across the entire life cycle through a comparison with current crew requirements

Modifying the CTE Assessment Process for Life Cycle Related Technologies (2 of 5)

- **Under certain circumstances, the supporting information should be augmented or tailored for the specific situation**
  - **When long-term effects cannot be accurately calculated analytically and the risk of a miscalculation is large**
  - **When amplification of the Deskbook supporting information will be helpful in assigning the proper TRL**



Modifying the CTE Assessment Process for Life Cycle Related Technologies (3 of 5)

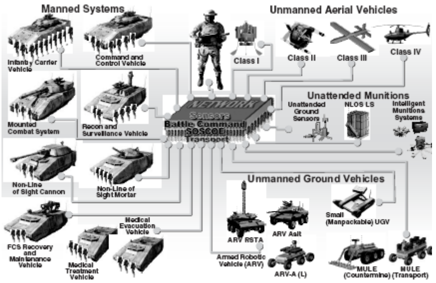
- **Technologies that improve reliability/maintainability and correspondingly reduce the logistics footprint and operating, support, or maintenance manpower requirements**
  - **Additional supporting information should focus on the performance of the end item**
    - **The C-5 Reliability Enhancement and Re-Engining Program (RERP) is a comprehensive effort to improve reliability, maintainability, and availability**
    - **Long-term commercial experience used to assess TRL 7 for new propulsion system**

Modifying the CTE Assessment Process for Life Cycle Related Technologies (4 of 5)

- **Technologies used to protect against the environment (may also protect the environment)**
  - **Additional supporting information should focus on the performance of the material being tested**
    - **Using advanced high solid-edge retentive tank coatings instead of solvent-based paints; representation of tanks represents the highest annual maintenance cost**
    - **TRL 7 based on long-term commercial data on service life; reduced inspection, cleaning, preparation, and painting; and labor to apply the new coatings**

Modifying the CTE Assessment Process for Life Cycle Related Technologies (5 of 5)

- **On-board and off-board technologies for analysis, status, or diagnosis of failure**
  - **Additional supporting information should focus on accuracy**
    - **The extensive use of predictive maintenance, conducted by networked on-board diagnostics and prognostics that pulse the system when issues arise (or are expected), is an important component of the Future Combat Systems (FCS)**
    - **When failures are random, physics-of-failure models do not exist; a statistical approach to prediction must be taken, but, data must be generated to support TRL greater than 4**



Additional Life-Cycle-Related Supporting Information Has Been Developed

<table>
<tr><th>Hardware TRL 6
Definition</th><th>Hardware TRL 6
Description</th><th>Hardware TRL 6
Supporting Information</th></tr>
<tr><td>System/subsystem model or prototype demonstration in a relevant environment.</td><td>Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology’s demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.</td><td>Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?</td></tr>
<tr><td colspan="3">Additional hardware supporting information
for technologies to improve reliability/maintainability
Analytical efforts at the subsystem level that estimate reliability (or reliability improvement if comparing to something already in existence). Efforts may encompass both an FMEA and failure-rate calculations for each of the subsystem failure mechanisms. Alternative corrective and/or preventive actions that could mitigate the most significant failure mechanisms should be identified. Maintainability analyses conducted to determine reliability-centered (failure-based) maintenance and condition-based maintenance strategies as well as a level of repair determination. Estimated support man-hours and spare parts’ needs meet expectations/requirements. Form-fit-function performance ensured.</td></tr>
<tr><td colspan="3">Additional hardware supporting information
for technologies used to protect against the environment
Material tested in a laboratory environment to provide assurance of its performance throughout its intended life cycle. Deliberately stressful/relevant environments are used to determine whether any degradation in performance occurs against known standards. Material interaction testing is conducted to ensure that no adverse chemical or other reactions occur in either the components being protected or other adjacent parts of the system.</td></tr>
<tr><th>Software TRL 6
Definition</th><th>Software TRL 6
Description</th><th>Software TRL 6
Supporting Information</th></tr>
<tr><td>Module and/or sub-system validation in a relevant end-to-end environment.</td><td>Level at which the engineering feasibility of a software technology is demonstrated. This level extends to laboratory prototype implementations on full-scale realistic problems in which the software technology is partially integrated with existing hardware/software systems.</td><td>Results from laboratory testing of a prototype package that is near the desired configuration in terms of performance, including physical, logical, data, and security interfaces. Comparisons between tested environment and operational environment analytically understood. Analysis and test measurements quantifying contribution to system-wide requirements such as throughput, scalability, and reliability. Analysis of human-computer (user environment) begun.</td></tr>
<tr><td colspan="3">Additional software supporting information for analysis technologies
Verify that faults can be detected/predicted using known faults in a simulated real environment such as a test cell or test platform not in use. Both Type I errors (actual faults not detected) and Type II errors (false positives) are within acceptable limits.</td></tr>
</table>

Best Practices for Life-Cycle-Related CTE Assessment

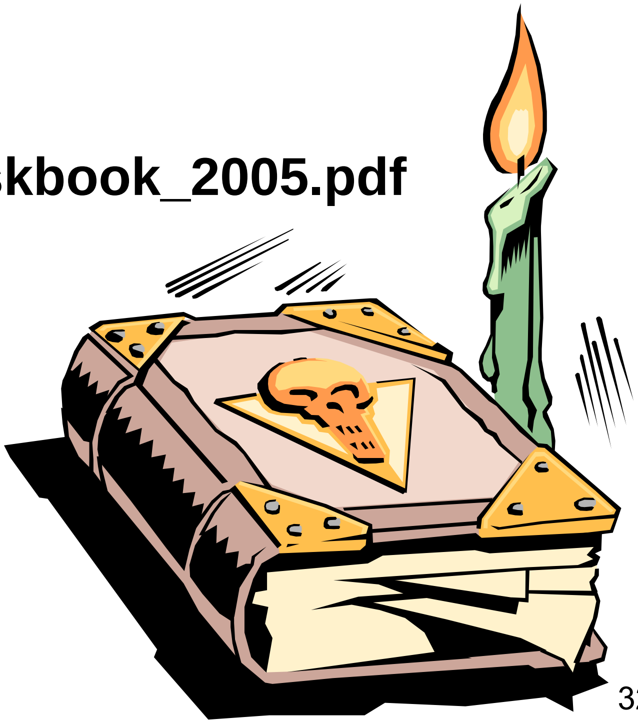
- **Include experts on appropriate LCR areas on the independent TRA panel, preferably the same ones used in the CTE identification process**
- **If the LCR CTE is also critical from a performance perspective, also determine a performance-related TRL**
  - **TRAs evaluate readiness to transition to the next phase of development**
  - **Therefore *all* aspects of their maturity should be assessed**

Outline

- Introduction to Technology Readiness Assessments (TRAs)
- Life-cycle-related (LCR) Critical Technology Element (CTE) identification
- Life-cycle-related Critical Technology Element assessment
- References and resources

References and Resources

- Defense Acquisition Resource Center
  http://akss.dau.mil/darc/darc.html
  - DoD Directive 5000.1 (DoDD 5000.1), *The Defense Acquisition System*, dated May 12, 2003
  - DoD Instruction 5000.2 (DoDI 5000.2), *Operation of the Defense Acquisition System*, dated May 12, 2003
  - *Defense Acquisition Guidebook*
- *TRA Deskbook*
  http://www.defenselink.mil/ddre/doc/tra_deskbook_2005.pdf
- DDR&E
  - Mr. Jack Taylor jack.taylor@osd.mil
- Institute for Defense Analyses
  - Dr. David Sparrow dsparrow@ida.org
  - Dr. Jay Mandelbaum jmandelb@ida.org



BACKUP

How TRAs Got Started

- **"Program managers' ability to reject immature technologies is hampered by (1) untradable requirements that force acceptance of technologies despite their immaturity and (2) reliance on tools that fail to alert the managers of the high risks that would prompt such a rejection."** ***GAO/NSIAD-99-162***

- **"Identify each case in which a major defense acquisition program entered system development and demonstration … into which key technology has been incorporated that does not meet the technology maturity requirement … and provide a justification for why such key technology was incorporated and identify any determination of technological maturity with which the Deputy Under Secretary of Defense for Science and Technology did not concur and explain how the issue has been resolved."** ***National Defense Authorization Act for Fiscal Year 2002***
- **"The management and mitigation of technology risk, which allows less costly and less time-consuming systems development, is a crucial part of overall program management and is especially relevant to meeting cost and schedule goals. Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition."** ***DoDI 5000.2, paragraph 3.7.2.2***

Stop launching programs before technologies are mature

Quantifying the Effects of Immature Technologies

According to a GAO review of 54 DoD programs:

- Only 15% of programs began SDD with mature technology (TRL 7)
  - Programs that started with mature technologies averaged 9% cost growth and a 7 month schedule delay
  - Programs that did not have mature technologies averaged 41% cost growth and a 13 month schedule delay
- At critical design review, 42% of programs demonstrated design stability (90% drawings releasable)
  - Design stability not achievable with immature technologies
  - Programs with stable designs at CDR averaged 6% cost growth
  - Programs without stable designs at CDR averaged 46% cost growth and a 29 month schedule delay

Source: Defense Acquisitions: Assessments of Selected Major Weapon Programs, GAO-05-301, March 2005

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Innovative Acquisition Methodologies In Support of Test & Evaluation Objectives

Jeff Manthos
US General Services Administration
March 12, 2007

U.S. General Services Administration

Federal Acquisition Service

Who are we?

- GSA Federal Acquisition Service…A New Service Representing
  - General Supplies and Services
  - Integrated Technology Services
  - Assisted Acquisition Services
  - Travel, Motor Vehicle, & Card Services

Today's Topic - Part One

- Acquisition, Innovation and the Industrial Base
- Enabling GSA "Tools" (Professional Services Schedule contracts)
- GSA Tools – T&E *Crosswalk*
- Innovation Examples

Today's Topic - Part Two

- The GSA Multiple Award Schedule Contract
- Basic Schedule Ordering Procedures
- Flexible Schedule Tools
- GSA E-Tools
- GSA Support

NDIA's Principle Missions

……………are to improve weapons technology, improve defense management, and maintain a strong science-industry-defense team continually responsive to all needs of the research, development, test & evaluation, production, logistics and management phase of national preparedness…..

Conference Objectives

- T&E Metrics for Suitability and Sustainability
- Reducing Total Ownership Costs and Role of T&E, SE, and Logistics
- Test Planning
- Planning and Implementing Sustainability as a KKP Effectively
- Design Techniques

Conference Objectives, Con't

- Test Methodology
- Testing for Realistic Estimates of Reliability
- Technologies to Reduce Life Cost
- Field Test Data & Archiving
- Feedback Sustainment Lessons to Improve Requirements, Programming T&E and Acquisition Process

Leveraging the Industrial Base for Test & Evaluation

- T&E Agencies
- Acquisition
- Industry

GSA can be the enabler!

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Commercial Item Acquisition

Expanding the use of commercial items in DoD systems offers the DoD opportunities for reduced cycle time, faster insertion of new technology, lower life-cycle costs, greater reliability and availability, and support from a more robust industrial base. It is a fact that for many technologies that are critical to military systems, the commercial marketplace-and not the DoD-now drives the pace of innovation and development.

DoD Extension to PMBOK ® Guide
June 2003

Acquisition Methodologies

- Full and Open
- Agency Organic Indefinite Delivery-Indefinite Quantity
- Set-Aside Programs
- Government-Wide Acquisition Contracts

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GSA Schedules Program

What is a Schedule?

- GSA Awarded Competitive IDIQ contracts
- Mirrors Commercial Buying Practices
- Long-term Contracts Awarded to Multiple Companies
  - 5 yrs. With Three 5-yr. Options
- Forty-three Schedules Offer 11 Million-Plus Products & Srv.
- Huge Selection: Over 14,000 Companies Represented on Nearly 18,000 Contracts

Multiple Award Schedule Features

- MAS Program Has Grown From $10 Billion in 1999 to over $35 Billion in 2006
- Service Schedules Pave the Way for Integrated Solutions
- Used Throughout DoD, DHS and Other Top Agencies
- Flexibility to Support Multi-Agency Strategic Sourcing Efforts
- Full Suite of Customized Online Tools
  - Air Force Advantage, Other Specialized Stores
  - e-Buy, e-Library
- Online Contract Terms and Conditions
- Spend Data Helps Agencies Manage More Effectively

Multiple Award Schedule Benefits

All Competition Requirements Have Been Met

- No Synopsis Required
- Prices Have Been Deemed Fair & Reasonable
- Terms and Conditions Have Been Pre-negotiated
- Reduced Need For Front-End Procurement Personnel

Continued

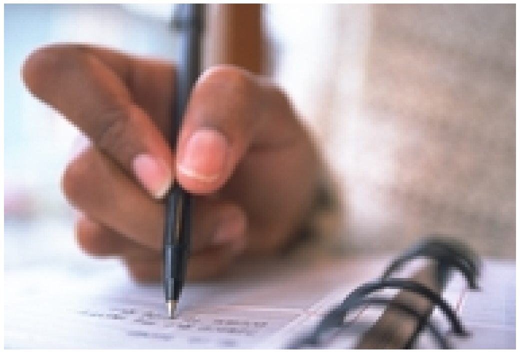
Multiple Award Schedule Benefits, Con't

- Reduced Procurement Lead Time
- Minimizes Documentation Required
- Customized Solutions
- Direct Relationship With Contractors
- No Additional Administrative Fees
- Risk of Protest is Low

Transparent Pricing

Task Order Type:

- Firm fixed price or FFP *(preferred)*
- Labor hour
- Time and Materials
- Incentives with FFP



The service contract act does not apply!

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Enabling Tools

GSA Professional Services Schedule Contracts

GSA Professional Services (samples)

- Professional Engineering Services
- Mission Oriented Business Integrated Services
- Logistics Services
- Environmental Services
- Laboratory Services

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Professional Engineering Services - Schedule 871

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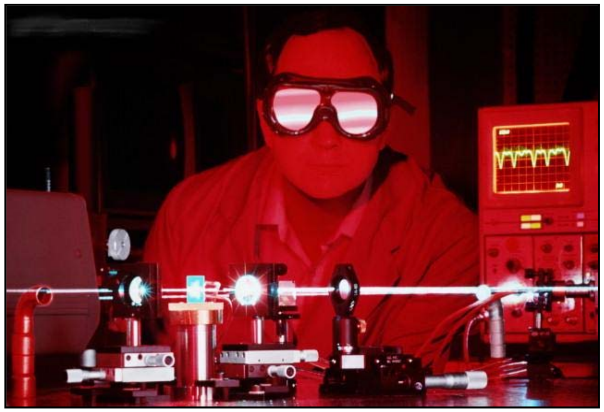
Professional Engineering Services Scope of Schedule

This schedule provides a comprehensive vehicle for Federal agencies to use when obtaining all types of engineering services



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Professional Engineering Services NAICS Codes

- 541330 Engineering services and
- 541710 Research and development in the physical sciences

Professional Engineering Services (Schedule 871) Industry Partners

- Over 800 Contractors as of January 2007, including:
  - Large Businesses
  - Small Businesses
    - Disadvantaged
    - HUBZone
    - Veteran-owned
    - SDVOB
    - Women-owned

Professional Engineering Services-871

- Special Item Numbers (SINs):
  - 871-1 Strategic Planning for Technology Programs/Activities
  - 871-2 Concept Development and Requirements Analysis
  - 871-3 System Design, Engineering and Integration
  - 871-4 Test and Evaluation
  - 871-5 Integrated Logistics Support
  - 871-6 Acquisition and Life Cycle Management

SIN 871-1

- Strategic Planning for Technology Programs/Activities

- …definition and interpretation of high-level organizational engineering performance requirements such as projects, systems, missions, etc.

SIN 871-2

- Concept Development and Requirements Analysis

  - …abstract or concept studies and analyses, additional requirements definition, preliminary planning and evaluation of alternative technical approaches…cost-performance trade-off analysis, feasibility analysis..

SIN 871-3

- Systems Design, Engineering and Integration

- …translation of a system or (subsystem, program, project activity) concept into a preliminary and detailed design (engineering plans and specifications), performing risks identification/analysis/mitigation, traceability…

SIN 871-4

- Test and Evaluation

- …application of various techniques demonstrating that a prototype system (subsystem, program, project or activity) performs in accordance with the objectives outlined in the original design….

SIN 871-5

- Integrated Logistics Support

- ….analysis, planning and detailed design of all engineering specific logistics support including material goods, personnel, and operational maintenance and repair of systems throughout their life cycles…..

SIN 871-6

- Acquisition Life Cycle Management

  - …planning, budgetary, contract and systems/program management functions required to procure and/or produce, render operational and provide life cycle support to technology based systems, activities, sub-systems, projects, etc…..

Mission Oriented Business Integrated Services (MOBIS)-874

- **Special Item Numbers (SINs):**
  - 874-1 Consulting Services
  - 874-2 Facilitation Services
  - 874-3 Survey Services
  - 874-4 Training Services
  - 874-5 Support Products
  - 874-6 Competitive Sourcing Support
  - 874-7 Program Integration and Project Management Services
  - 874-99 Introduction of New Services

MOBIS Schedule NAICS Codes

- 541611Administration Management & General Management Consulting Services

Some MOBIS Tasks

- Quality Management
- Business Process Re-engineering
- Strategic & Business Planning
- Benchmarking
- Competitive Sourcing
- Activity-Based Costing
- Financial Management Analysis (related to improvement effort)

More MOBIS Task Examples

- Statistical Process Control
- Surveys
- Individual & Organizational Assessments & Evaluation
- Process Improvements
- Process Modeling and Simulation
- Performance Measurement

Logistics Worldwide (Logworld)-874V

- **Special Item Numbers (SINs):**
  - 874-501 Supply & Value Chain Management Services
  - 874-502 Acquisition Logistics
  - 874-503 Distribution & Transportation Logistics Services
  - 874-504 Deployment Logistics
  - 874-505 Logistics Training Services
  - 874-506 Support Products
  - 874-507 Operations & Maintenance Logistics Management and Support Services

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Logistics Worldwide Schedule NAICS Codes

- 541614 Process, Physical Distribution, and Logistics Consulting Services
- 561210 Facilities Support Services

Some LOGWORLD Tasks

- Design & Fabrication (in support of a logistics effort/process)
- System Testing
- Range & Communications Engineering (But any IT must be related to logistics application/task. No volume purchases or software development not related to Logistics tasks.)
- Remote site logistics support (National & International)
- Food Service / Motor Pool / Courier Service

More LOGWORLD Tasks

- Spares Support (to include purchase support if items are listed on GSA contract)
- Inventory Management
- Analysis of Distribution Points – Air, Road, Water, Rail or Pipeline
- Material Handling Training / Forklift Certification
- Planning (Scenarios, databases, after action review support, archive operational lessons learned)
- Train and mentor foreign military services in logistics methods and techniques

Environmental

- **Special Item Numbers (SINs):**
  - **899-1 Environmental Planning Services & Documentation**
  - **899-2 Environmental Compliance Services**
  - **899-3 Environmental Occupational Training Services**
  - **899-4 Waste Management Services**
  - **899-5 Reclamation, Recycling and Disposal Services (This does NOT include handling/disposal and/or transportation of nuclear or radioactive waste.)**
  - **899-6 Remote Advisory Services**
  - **899-7 Geographic Information Services (GIS)**
  - **899-8 Remediation Services**

Environmental Schedule NAICS

- 541620 Environmental Consulting Services
- 562920 Material Recovery Facility
- 562112 Hazardous Waste Collection
- 541380 Lab Services *[check scope]*
- 562910 Remediation Services

Some Environmental Tasks

- Environmental Impact Statements
- Develop programs or regulations
- Risk Analysis or Vulnerability Assessments
- Environmental Compliance Audits
- Spill Prevention
- Environmental Training
- Permitting
- Waste Management Plans or Studies
- Establish/operate HAZMAT, electronics, CRT, battery or chemical recycling programs

Laboratory Testing and Analysis Services

(Now part of Schedule 66)

- Special Item Numbers (SINs):
  - 873-1 Mechanical Testing and Analysis
  - 873-2 Chemical Testing and Analysis
  - 873-3 Electrical Testing and Analysis
  - 873-4 Geotechnical and Thermal/Fire Testing and Analysis
  - 873-99 Introduction of New Testing and Analysis

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GSA Tools – T&E *Crosswalk*

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T&E Metrics for Suitability and Sustainability

- SIN 871-6 Acquisition Life Cycle Management
- SIN 874-502 Acquisition Logistics
- SIN 871-5 Integrated Logistics Support
- SIN 874-7 Program Integration and Project Management

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Reducing Total Ownership Costs and Role of T&E, SE and Logistics

- SIN 871-6 Acquisition Life Cycle Management
- SIN 871-2 Concept Development and Requirements Analysis
- SIN 871-5 Integrated Logistics Support
- SIN 874-7 Program Integration and Project Management

Test Planning to Assure Priority for Assessment of S&S

- SIN 871-3 Systems Design, Engineering and Integration
- SIN 871-4 Test and Evaluation
- SIN 874-1 Consulting Services
- SIN 874-7 Program Integration and Project Management

Planning and Implementing Sustainability as a KKP Effectively

- SIN 871-3 Systems Design, Engineering and Integration
- SIN 871-4 Test and Evaluation
- SIN 871-5 Integrated Logistics Support
- SIN 874-7 Program Integration and Project Management

Design Techniques such as Conditioned-Based Maintenance and its T&E

- SIN 871-3 Systems Design, Engineering and Integration
- SIN 871-4 Test and Evaluation

Test Methodology

- SIN 871-2 Concept Development and Requirements Analysis
- SIN 871-3 Systems Design, Engineering and Integration
- SIN 871-4 Test and Evaluation
- SIN 874-1 Consulting Services (MOBIS)

Testing for Realistic Estimates for Reliability

- SIN 871-Test and Evaluation
- SIN 874-7 Program Integration and Project Management

Reducing Total Cost of Ownership

- SIN 871-1 Strategic Planning for Technology Programs
- SIN 871-5 Integrated Logistics Support
- SIN 871-6 Acquisition Life Cycle Management
- SIN 874-1 Consulting Services (MOBIS)

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Technologies to Reduce Life Cycle Cost

- SIN 871-1 Strategic Planning for Technology Programs
- SIN 871-2 Concept Development and Requirements Analysis

Field Test Data and Archiving

- SIN 871-4 Test and Evaluation
- SIN 871-6 Acquisition Life Cycle Management
- SIN 874-7 Program Integration and Project Management

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Feedback Sustainment Lessons to Improve Requirements, Programming T&E and Acquisition Process

- SIN 874-1 Consulting Services (MOBIS)
- SIN 871-5 Integrated Logistics Support
- SIN 871-6 Acquisition Life Cycle Management
- SIN 874-7 Program Integration and Project Management

INNOVATION Examples-CTAs, BPAs

1. NASA Marshall Space Flight Center
   - One Schedule
   - One Task Order, One Contractor
2. Marine Corps Systems Command
   - Eight Schedules
   - Multiple-Award BPA, Many Contractor Teams

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NASA: One Schedule, One Task Order

A. Select Schedule

Aggregated Requirement

- Logistic Support Services
  - Property
  - Mail
  - Move
  - Disposal
  - Motor Pool
  - Equipment Maintenance
  - Environmental
  - Food

B. Select Applicable SINs

Logistics Worldwide (LOGWORLD) Schedule 874V

- SIN 874-501 Supply & Value Chain Mgmnt
- SIN 874-502 Acquisition Logistics
- SIN 874-503 Distribution & Transportation
- SIN 874-504 Deployment Logistics
- SIN 874-505 Logistics Training
- SIN 874-506 Support Products
- SIN 874-507 Operations and Maintenance Logistics Management & Support

MARCORSYSCOM Requirements

Multiple diverse program offices (each $20M+ annually)

- Information Systems & Infrastructure
- Battle Management/Air Defense
- Infantry Weapons Systems
- Armor & Fire Support
- Transportation/Engineering Systems
- Combat Equipment Support Systems

Solution: Multiple BPAs, Multiple CTAs

- All requirements met through Schedules
  - $3.6B+ annually (supplies & products)
  - $180M+ annually (services)
  - $340M+ total GSA Task Orders (through May 2005)
  - GSA Task Orders ranging from $150K to $6M each
- 27 Contractor Teams, 27 Multiple-Award BPAs
- 150+ Schedule contractors

Multiple-Schedule Solution

Specialty Engineering

874 MOBIS
871 Engineering
899 Environmental
70 IT

Business & Analytical

874 MOBIS
520 Financial & Business
69 Training

Engineering & Scientific

874 MOBIS
871 Engineering Services
70 IT

Acquisition, Log. & Admin.

874 MOBIS
874 V LOGWORLD
871 Engineering

Multiple BPAs & Contractor Teams

Specialty Engineering

- **FY05**: 8 BPA Teams
- **Avg. Team Size**: 11
- **Team Leads**: AOT, AT&T, Battelle, CSC, EMA, ManTech, MTC, Unitech

Business & Analytical

- **FY05**: 4 BPA Teams
- **Avg. Team Size**: 8
- **Team Leads**: Booz-Allen, Kalman, MCR, RCI

Engineering & Scientific

- **FY05**: 8 BPA Teams
- **Avg. Team Size**: 12
- **Team Leads**: AERA/EDO, Anteon, BAE, DCS, NGMS, OSEC, Sverdrup, SAIC

Acquisition, Log. & Admin.

- **FY05**: 7 BPA Teams
- **Ave. Team Members**: 11
- **Team Leads**: CACI, EG&G, INS, MKI, Titan, BRTRC, CRC

Examples: Using CTAs & BPAs for Complex Requirements

- Marine Corps Systems Command
  www.marcorsyscom.usmc.mil/sites/acss/
- Army Aviation and Missile Command
  https://wwwproc.redstone.army.mil/acquisition/omnibus2

PART TWO

- The GSA Multiple Award Schedule Contract
- Basic Schedule Ordering Procedures
- Flexible Schedule Tools
- GSA E-Tools
- GSA Support

Multiple Award Schedule Contract

Schedule Contract Features

- Streamlined Ordering
- Best Value
- Blanket Purchase Agreements
- Teaming Arrangements
- Maximum Order Provisions
- E-Tools

Streamlined Ordering

- Under $3,000
  - Select any Schedule Contractor

(The Micro Purchase Threshold for Davis Bacon Act Procurements is $2,000.
The Micro Purchase Threshold for Service Contract Act Procurements is $2,500.)

- Over $3,000
  - Send RFQ to a Minimum of 3 Schedule Contractors
  - Review the Quotes Received (can use GSA e-Buy)
  - Select the "Best Value" Based on Other Evaluation Factors in Addition to pricing
  - Issue a Task Order/Delivery Order

Awards Based on Best Value

Best Value is Determined on What is Important to the Buyer

- Price
- Technical Solution (including program management)
- Corporate Experience
- Past Performance
- Delivery

Blanket Purchase Agreements

- BPAs Offer Flexible Solutions and Options
- Build Long Term Relationships With Vendor Partners
- Useful for Replacing Expiring IDIQs
- Easy to Establish
  - Establish BPA From the Pool of Schedule Contractors
  - Used to set up “Accounts” to Fill Recurring Requirements
  - Can Last as Long as the Contract Period
  - Review Annually for “Best Value”
  - May be Offered Volume Discounts When Establishing a BPA

Contractor Teaming Arrangements

- Schedule Contractors May Team With Each Other to Provide a Total Solution for a Customer
- Best for Complex Acquisitions
- Enables Contractors to Consolidate Unique Capabilities
- Offers the Government the Best Combination of Performance, Cost and Delivery
- Increases Small Business Participation
- CTA Team Leader Responsible for Task Order Execution, Even If Not Identified

Maximum Order Provisions

- Customer Agencies Must:
  - Seek Additional Price Reductions
  - 3+ Contractors for Further Competition

- Contractors can:
  - Offer a Lower Price
  - Offer the Current Contract Price
  - Decline the Order

GSA Schedule Contract Fundamentals

- Standing solicitation - offers accepted throughout the year with no closing date (uniform updating, mass mods conform all Schedule contracts to existing solicitation)
- Part 12 Multiple Award IDIQ (FFP w/EPA)
- Task Orders (FFP, LH, and/or T&M)
- Three 5-year option periods
  - Task Order performance could extend beyond since performance continues even if Schedule option not exercised (or contract terminated)
  - However, agency couldn't award <u>new orders</u> or exercise <u>options</u> on TOs/BPAs without existing Schedule contract

Pricing & EPA Methods

1. **Established Commercial Price List/Equivalent**
   Requires a Modification Request from Contractor for Increase to Take Effect
2. **Negotiated Escalation Prior to Award**

A. **Fixed Escalation for Term of Contract (Multi-Year Pricing 20 Years)**
   Price Increases Automatically Effective on the Anniversary of Contract (No Modification)

B. **Adjustments Based on Market Indicator (Yearly Mod)**
   Based on a Published Index, Survey or Market Indicator

Are Schedule Prices the Best Prices?

- **Contract Level**
  - Contract Pricing Objective: "Most Favored Customer"
  - Price Reductions Clause
  - Inspected during contractor assist visits
  - Ordering agencies pay no fee to GSA to use the Schedules

- **Task Order Level**
  - Shall seek discounts (FAR 8.405-1(d)) if:
    - Task Order exceeds "Maximum Order Threshold"
    - BPA regardless of estimated value
  - Encouraged to seek discounts for all orders
  - Make best-value determination, total price/LOE/labor mix reasonableness

CONTRACT TERMS and CONDITIONS

- **What Does the Schedules Contract Say?**
- **Where Can I Read the Contract Clauses?**

Search FedBizOpps Schedule RFP

- Standing solicitation periodically replaced (GSA says "refreshed")
- All contracts updated with mass modifications to match the most recent FedBizOps-posted "refresh"
- Opens as a searchable *Word* document
- Use <Edit> <Find> in *Word* to locate words or phrases of interest.
- Good method both for numbered clauses and for other "free text"

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Federal Acquisition Service

GSA Schedules e-Library

GSA Advantage | e-Buy

Home | Federal Supply Schedule Listing | Basic Schedule Ordering Guidelines | Help

Search: [ ] all the words Go

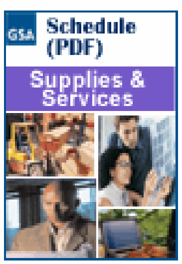
Schedule Summary

For general schedule questions, contact:

Phone: 1-800-241-RAIN

E-mail: environmental@gsa.gov

899 **ENVIRONMENTAL SERVICES**



GSA Contracts Online
Federal Buyers...
View Contract Clauses

Vendors
Click here to view the current solicitation on FedBizOpps

899 Category list: - Categories - Go

Category	Description
899 1	Environmental Planning Services & Documentation - Services to include, but not limited to: Environmental Asses

GSA

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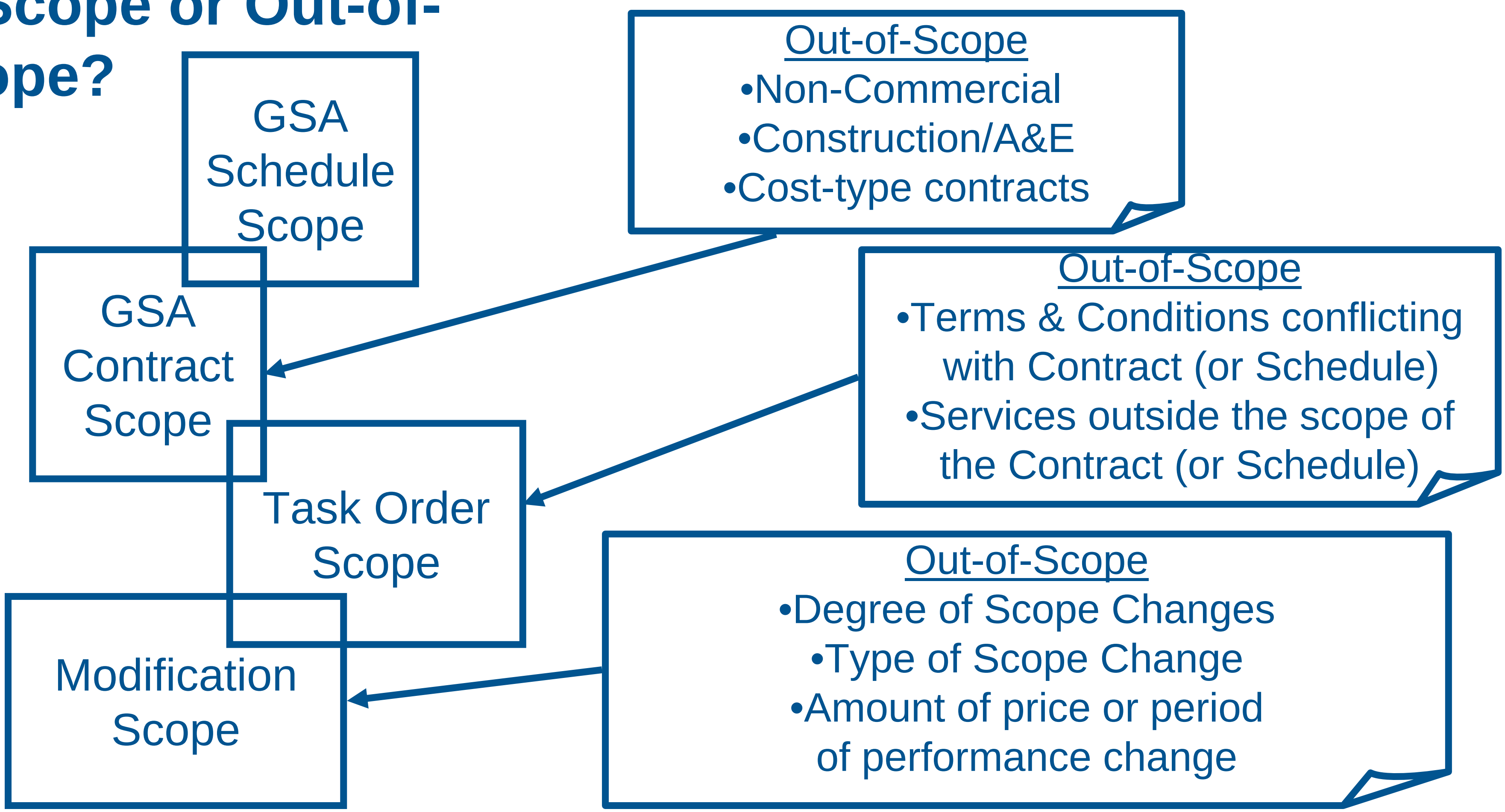
Federal Acquisition Service

BASIC SCHEDULE ORDERING PROCEDURES

&

TASK ORDER CONTRACTING

In-Scope or Out-of-Scope?



Some Limitations

- Broad Acquisition Limitations
  - Commercial Services
  - Personal Services
  - Inherently Governmental Functions
- Schedules Program Limitations
  - Architect/Engineer Contracts
  - Cost-Reimbursement Type
  - Construction

Ordering Procedures & Issues

- Schedules as Priority Source
- Ordering (RFQ Process, Quotes, Evaluation)
- Types of Orders
- GSA Orders vs. Open Market Procurement
- “Other Direct Costs”

The Basic Schedule RFQ Process

- Requirements Identification
- Market Research
- Acquisition Planning
- Develop Performance Work Statement
- Develop & Distribute RFQ (w/ Selection Factors)
- Evaluate Quotes Received
- Task Order Award

Prepare & Distribute RFQ

- Select non-conflicting order clauses
- FAR Clauses for Commercial Items [in GSA Schedule contract already]
- Define quote submittal requirements
- Establish offer/quote deadline
- Obtain necessary approvals (AAS, etc.)
- Provide to Schedule holders (e-mail, *eBuy*, fax)

Contents of RFQ for GSA Task Order (Keep It Simple)

- What Does the Government Think is Important for Award? (Evaluation Factors)
- What Does the Government Need to See? (Quote Submittal Instructions)
- What Are the Order’s Terms & Conditions (if any) Not Already in the Schedule Contract? (add non-conflicting clauses)
- What Will the Contractor Do? (PWS)

GSA Ordering

- 8.404(a) – Orders placed against a MAS using the procedures under this subpart are considered to be issued using full and open competition
- Micropurchase: Place orders with any Schedule contractor, but should "rotate" buys.
- Micropurchase to Maximum Order Threshold (MOT): Provide RFQ (PWS + Eval Factors + Submittal instructions) to at <u>least three</u> contractors
- Above MOT or if establishing BPA: As above plus an "appropriate number of additional contractors"

Receive & Evaluate Quotes

- Oral Proposals?
- Clarification of Minor Irregularities & Errors
- Technical Review
- Past Performance Review
- Communications ("Negotiation")
  - - Discount from GSA Schedule Price
  - - Reasonableness of Labor Mix/Total LOE

Best Value Evaluation

- The expected outcome of an acquisition that, in the Government's estimation, provides the greatest overall benefit in response to the requirement.
- Best Value Continuum: From *price predominates* (Low-Price Technically Acceptable) to *technical/past performance predominates*
- Best Value permits tradeoffs between <u>price</u> and <u>non-price factors</u>. The ordering activity may be willing to pay more for:
  - Achieving Socioeconomic Objectives (but not "Set Aside" Task Orders)
  - Better Past Performance
  - Better Technical Approach
  - Better Management Capability

Level of Effort Task Orders

- Time & Material [FAR 16.601]
  - Direct labor at fixed, hourly, fully-burdened rates
  - Materials at cost and handling costs
- Labor Hour [FAR 16.602]
  - Like T&M, but contractor supplies no materials

- Fixed Price is preferred over LOE
  - Like Cost-Reimbursement, no contractor incentive for cost control
  - Requires more surveillance and control than FFP
  - Use only where duration and extent of work cannot be estimated
  - CO determination, sometimes higher approval, required
  - Include ceiling price contractor exceeds at its own risk

GSA Orders (vs. Open Market)

- No FedBizOps synopsis for GSA Orders
- Prices on *FSS Authorized Price List* (GSA web-posted) already determined fair & reasonable, but Ordering Officer determines Best Value and reasonableness of overall LOE and labor mix.
- Competition (CICA) requirements already met, no competing outside Schedules
- Unrestricted (not “Set Aside” but can be eval factor), except for certain Schedules/SINs set aside by GSA

Other Direct Costs (ODCs)

- Three Categories of ODCs
  1. Contract Support Items (<u>on</u> Schedule contract)
  2. Open-market items ("Incidentals") (<u>not</u> on Schedule contract)
  3. Reimbursables: Lodging, Transportation & Per Diem
- All ODCs must be within the scope of the contract and awarded SIN
- ODCs support, are <u>not</u> the primary purpose of the order
- ODCs may <u>not</u> duplicate costs already included in the contract price
- ODC prices must be determined fair and reasonable by a CO (Schedules level or Task Order level)

1. Contract Support Items

- Commercial Items
- Items included in the MAS contract
  - Contract award
  - Added by Schedule contract modification
  - Not to be separately ordered without the services
- Items for which the Schedule CO has already determined the price fair and reasonable
- Example: items awarded, priced, and listed under a “Support Products” SIN (but separate *product-only* SIN <u>not</u> required)

2. Open-Market Items ("Incidentals")

- Items not awarded under that Federal Supply Schedule contract
- No assumption of price reasonableness (or scope)
- Schedule T&Cs don't apply unless cited
- Open-market items purchased IAW all applicable acquisition regulations:
  - FAR Part 5 – Publicizing contract Actions
  - FAR Part 6 – Competition Requirements
  - FAR Part 12 – Acquisition of CI's
  - FAR Part 13 – Simplified Acquisition Procedures
  - FAR Part 14 – Sealed Bidding
  - FAR Part 15 – Contracting by Negotiations
  - FAR Part 19 – Small Business Programs

3. Travel Reimbursables

- Federal Travel Regulation
  - 41 CFR, Chapters 300 – 304
  - Travel policies for Federal civilian employees and others authorized to travel at Gov't expense
- Joint Federal Travel Regulations
  - USC, Title 37 and 10
  - Availability of contract fares or prices to government contractors
- Local travel in the performance of a task order
  - Reimbursable IAW ordering agency regulations

FAR Parts Not Applicable to Schedule Orders/BPAs

- Synopsis requirements in Part 5
- All of Part 6 (8.405-6 is “Limiting Sources”)
- All of Part 13 (except 13.303-2(c)(3))
- All of Parts 14 and 15
- All of Part 19 (except 19.202-1(3)(iii))

However, if mixing open-market items (total over micropurchase) then <u>all regulations</u> apply to those items.

"Limited Source Justification" GSA Sources

- Only one source capable of responding due to the unique or specialized nature of the work
- New work is a logical follow-on to an existing order (excluding previous orders placed previously under sole source requirements)
- Item is peculiar to one manufacturer (a brand name item, available on various Schedule contracts, is an item peculiar to one manufacturer); or
- An urgent and compelling need exists and following the ordering procedures would result in unacceptable delays

How Can Need for Quoted Open Market Products Be Reduced?

- Contractor requests GSA CO to add to contract by modification
- Agency preference for all-Schedule order (Schedule contractors team)
- Agency procures and furnishes as GFP/GFE (need those clauses in Task Order)

Pricing in Task Order Quotes

- Compare with website *GSA Advantage* price list
- Scrutinize non-Schedule services & items
- Labor rates on Schedule contract are already fully- loaded
- Question additional G&A, esp. on travel (paying twice?)
- Don’t pay a separate “Industrial Funding Fee” (that 0.75% already included in contract price)
- If concerned about what is included in price, contact the GSA CO
- Contract labor rates assume “normal” bid & proposal expense - - may get “no quote” if unusual quote requirements for Task Order/BPA

Flexible Schedule Tools

- Blanket Purchase Agreements (BPAs)
- Contractor Teaming Arrangements (CTAs)

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Blanket Purchase Agreements

Why Establish MAS BPA?

- Satisfy recurring requirements
- Reduce administrative burden
- Leveraging buying power through volume
- Support field offices/other contracting offices
- Quicker order turn-around
- Can incorporate non-conflicting terms & conditions
- Can include contractor teaming
- No funding required to establish BPA
- No synopsis, no competition outside Schedules to establish or use BPA
- Opportunity to negotiate better discounts

Blanket Purchase Agreements

- Simplified Acquisition Method
- Anticipated Repetitive Needs
- Qualified Source(s)
- Single or Multiple Award

The Contractor's Perspective

•Recurring source of orders
•Volume
•Quicker turnaround on orders
•Expectation of price discounting

The Government's Perspective

•Flexibility in exact services, quantities, and period of performance
•Efficiencies by having summary invoicing and consolidated payment
•Expectation of best pricing for each Task Order

What's in a BPA?

- Estimated value/level of effort (not a ceiling)
- Duration
- GSA Schedule(s) & Contract(s)
- Participating offices/agencies
- Invoicing/billing procedures
- Ordering procedures (if multi-award)
- Terms & conditions
- Discount terms
- Types of orders to be placed
- Scope
- BPA Termination

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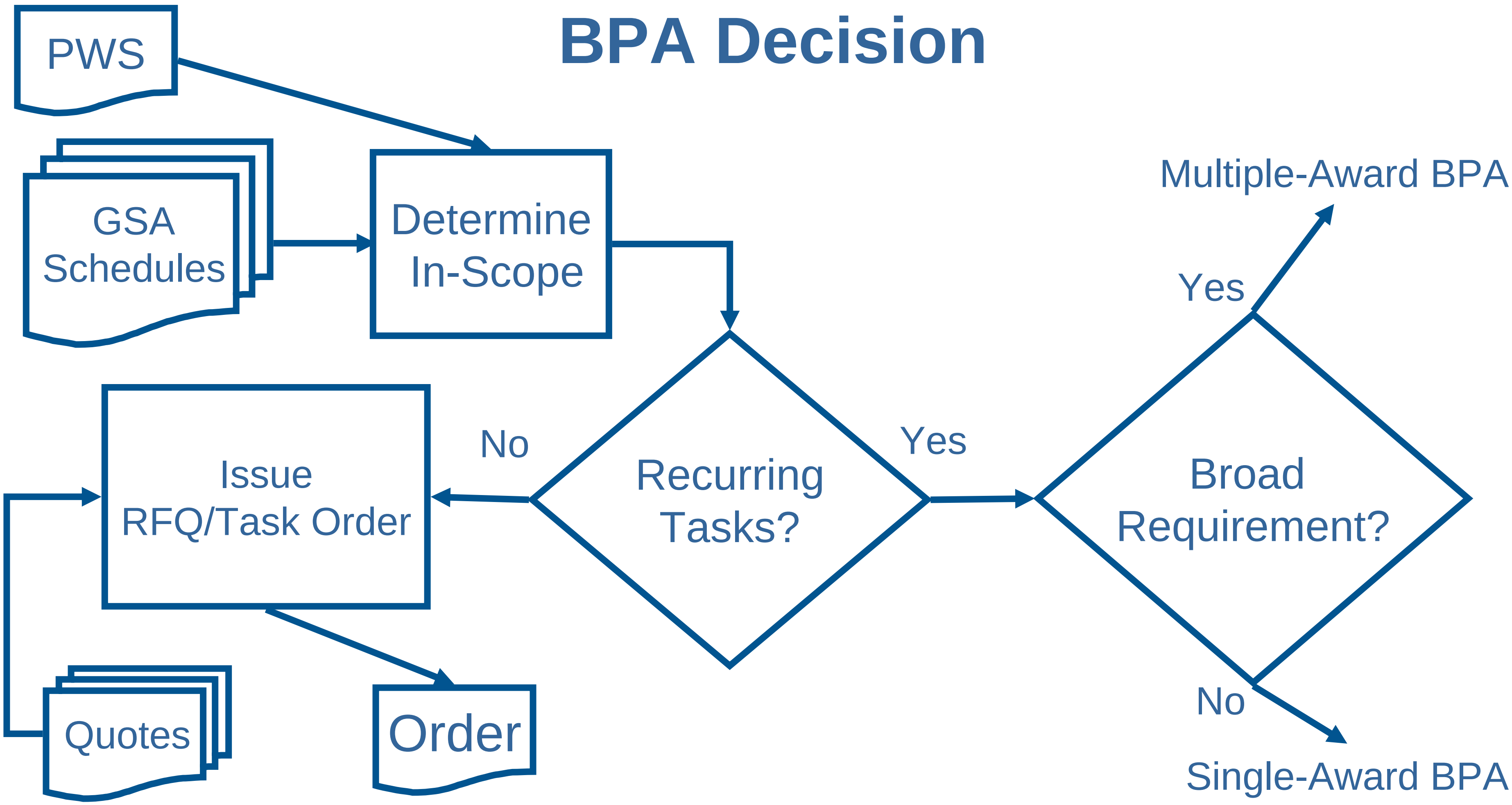
BPA Decision



Single-Award BPA

- Receive & Evaluate BPA Quotes
- *Award One BPA*
- Issue BPA RFQ (PWS)

Then, for Each Recurring Task:

- Award Task Order
- Issue Task Order RFQ (PWS) *to sole*
- Evaluate the Quote
- BPA-holder

Multiple-Award BPA

1. Issue BPA RFQ (PWS)
2. *Award Multiple BPAs*
3. Receive & Evaluate BPA Quotes

Then, for Each Recurring Task:

1. *Develop Task Order Evaluation Criteria*
2. Issue Task Order RFQ (PWS) *to all BPA-holders*
3. Evaluate the Multiple Quotes*: Best-Value Source Selection*
4. Award Task Order

Two Best Value "Competitions": Who Gets the BPA? Who Gets the Task Order?

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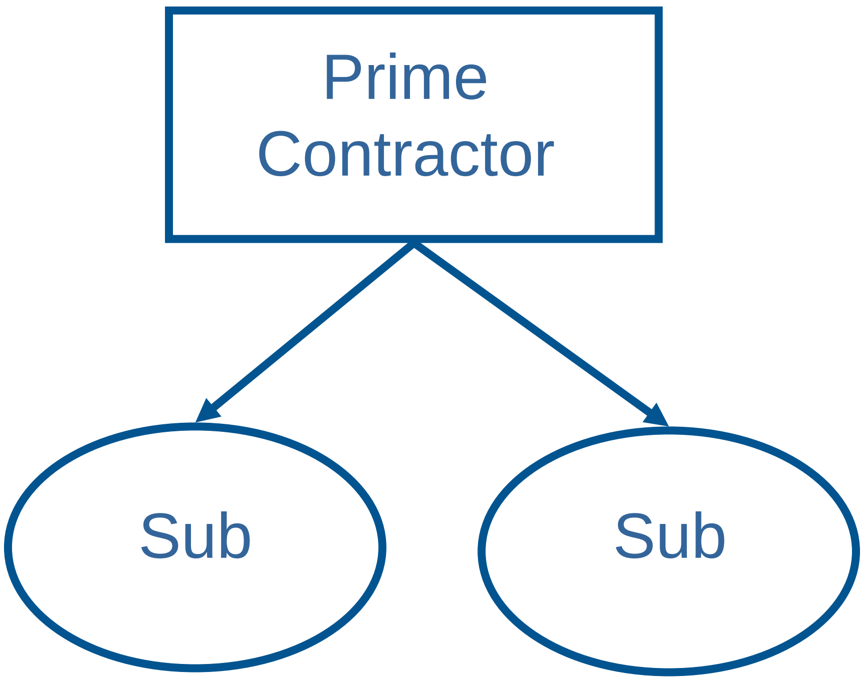
Contractor Teaming Arrangements

Subcontracting vs "Teaming"

- Only Prime must have a Schedule contract
- Only Prime has privity of contract (and interface) with Government
- Ordered and invoiced at Prime's Schedule rate (less discount)
- Limited to SINs and labor categories on a single Schedule contract
- Prime can't "delegate" responsibility

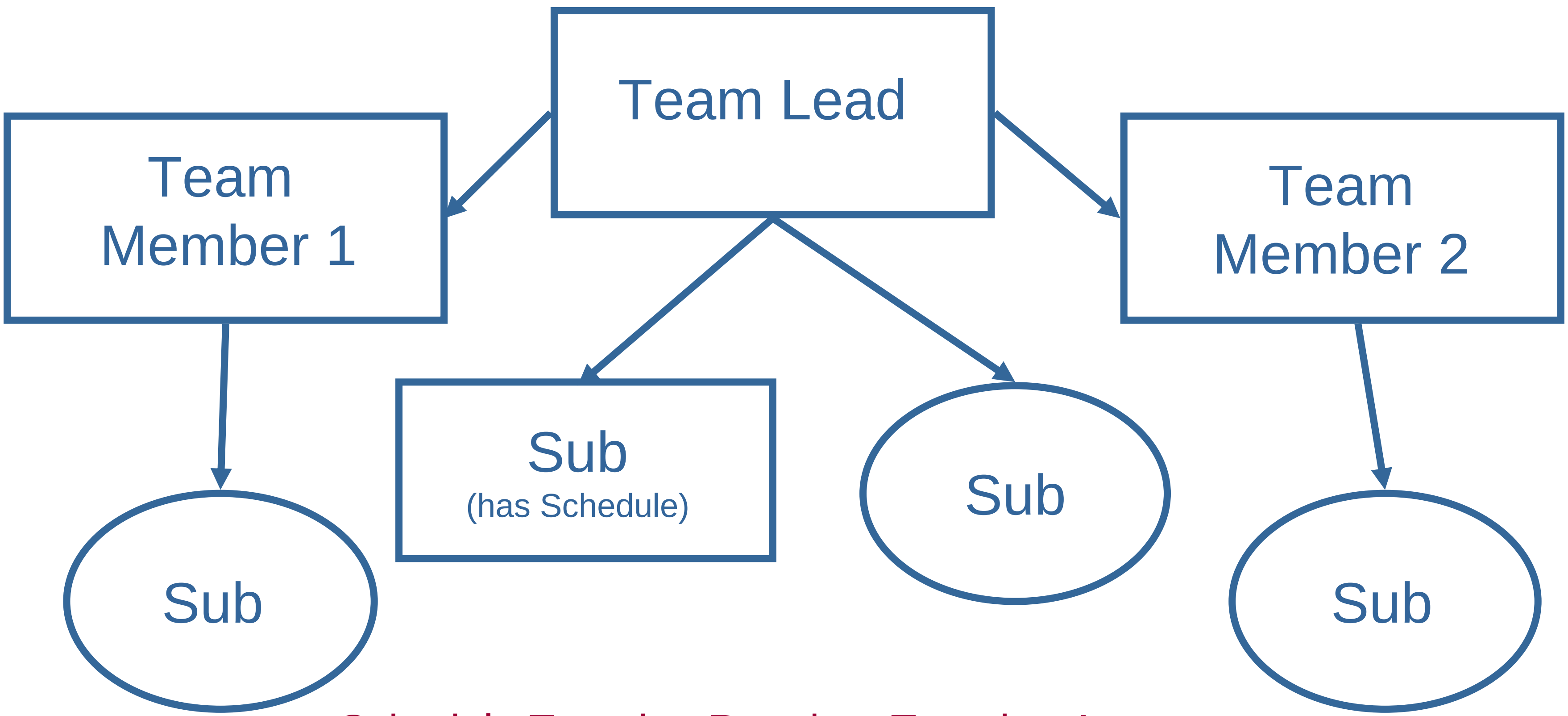
- Each Team Member must have a Schedule contract
- Each Team Member has privity of contract (and can interface) with Government
- Ordered and invoiced at each Team Member's Schedule rate (less discount)
- Total Schedule solutions possible
- Each member can be responsible for duties in a teaming agreement

Prime/Subcontractor Relationship



BPAs/Orders Only to Prime (Schedule Contractor)

MAS Teaming and Subcontracting



Schedule Teaming Requires Teaming Agreement

MAS CTAs

- Team Leads & Members must have GSA Schedule and use their Schedule rates
- Contractor Teams are issued one BPA
- Could include subcontractor effort, as long as mapped to their Prime's Schedule labor category
- If Multi-Award BPA, Teams compete for Task Orders
- Task Orders can be issued to Team Lead or directly to Team Member
- Not a separate legal entity but acts *like* joint venture
- Include Teaming Agreement with quote for agency review
- Government incorporates CTA into BPAs/Orders

CTA Can Reduce Need for Open-Market Items on a GSA Task Order!

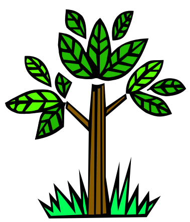
Teaming Agreement Highlights

- Identify Parties (Members and Lead)
- Teaming Activities (w/ responsibilities)
- Type & Duration of Agreement
- CTA Terms
- Ordering Procedures
- Team Lead & Team Member Duties
- Pricing, Invoicing, and Payment
- Performance Responsibility/Evaluation
- Reporting Sales to GSA
- Warranty
- Confidential Information

Agreement is solely between the Members, can't conflict with Schedule

CTAs and BPAs: Putting It All Together


Aggregate




Your Requirements

- Use Single/Consolidated Schedule
- Task Award to a Single Contractor

- Use Several Schedules
- Award BPAs
- Contractors Team

Two Ways to Satisfy Multi-Domain (Schedule/SIN) Requirements

1. One GSA Contractor holds all needed domains, so teaming not required:

   a. As separate single-Schedule contracts, and/or

   b. On the Consolidated Schedule

<u>OR</u>

2. GSA Schedule holders team across domains.

Consolidated Schedule

- Only for contractors with two or more Schedules (e.g., PES and MOBIS)
- One GSA contract, so just one Task Order for agency to award/administer
- Contractor can offer their entire business line on a single contract
- Includes most service Schedules and some related product Schedules (including IT)

E-Tools: Bringing Buyers and Sellers Together

- GSA *Advantage!*®
- e-Buy
- e-Library

Market Research Tools

Market Research Web Address

Schedules E-Library
www.fss.gsa.gov/elibrary

GSA *Advantage!*®
www.gsaAdvantage.gov

GSA e-Buy
access through GSA *Advantage!*®
www.gsaAdvantage.gov

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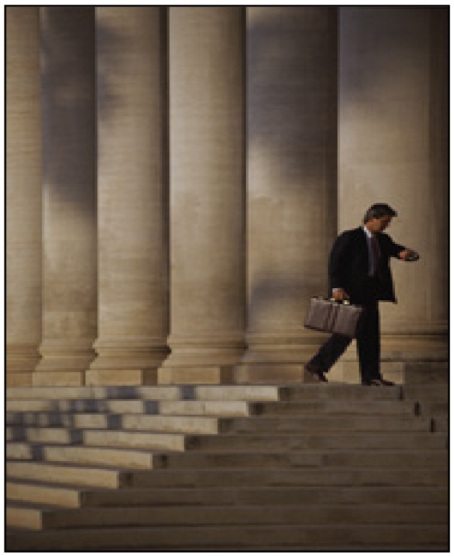

GSA Support

Support Provided By GSA

- Agency outreach: guidance, training & education
- Industry outreach: promote, facilitate the growth of schedules supplier base
- Expedite awards/mods of “potential” suppliers

GSA Support (continued)

Value added assisted procurement service or agency in-house buying are customer options.

Assisted Services Support Provided By GSA

- Acquisition management
- Program management
- Financial management

Costs to Use GSA

- No additional administrative fee for in-house buying (IFF built into rates)
- Competitive negotiated fee for procurement service

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Federal Acquisition Service

THANK YOU!

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Perspectives on Testing for Operational Suitability and Life Cycle Sustainability

for the

23rd National Test & Evaluation Conference

RDML Bill McCarthy
COMOPTEVFOR
13 March 2007

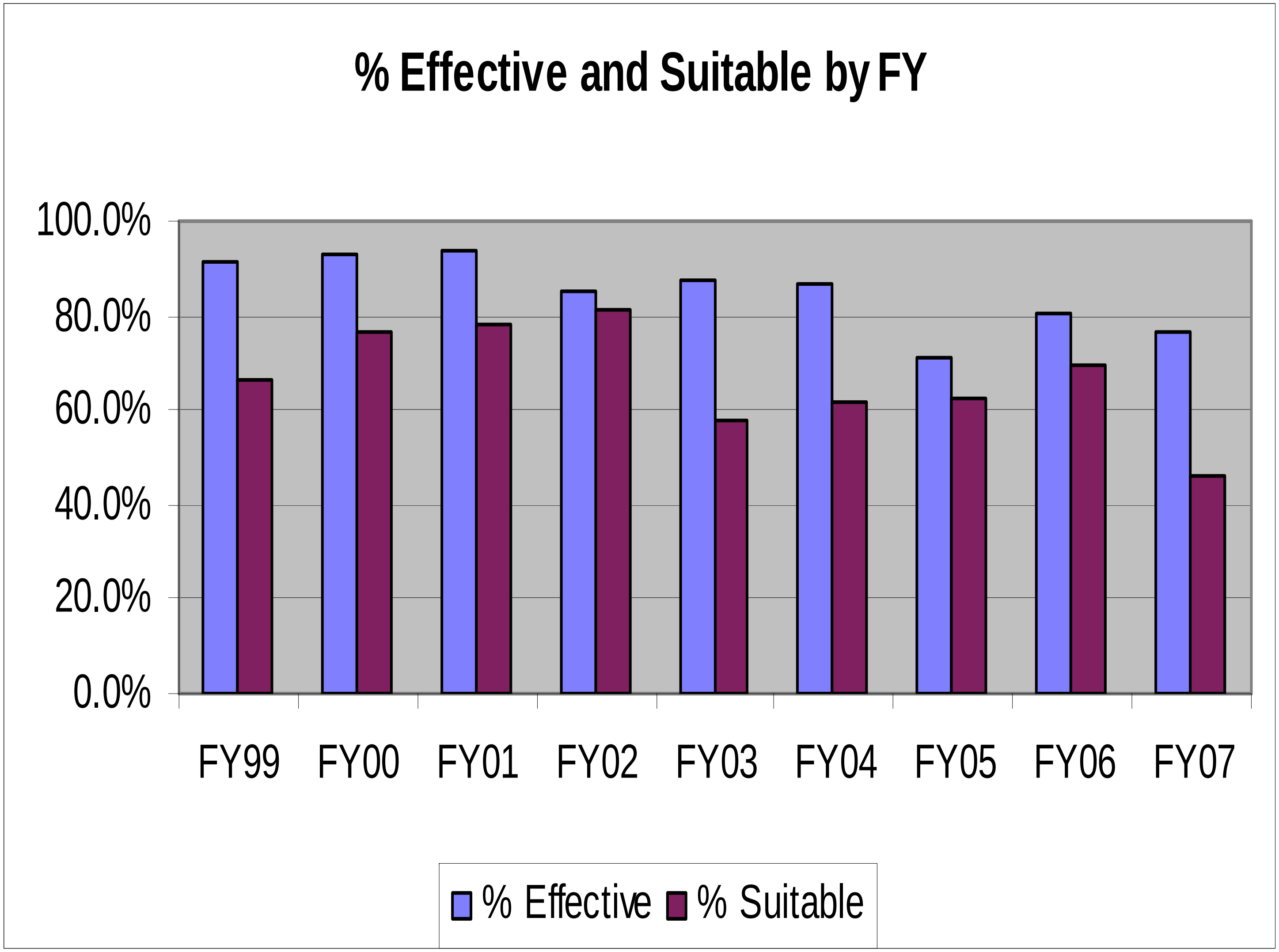
The Challenge

- To provide the warfighter with the tools needed to win the current “Long War” while building a force to meet future threats –
  - Do more
  - Do it faster
  - Do it with fewer resources
  - ***Do it with an understanding of the true cost***

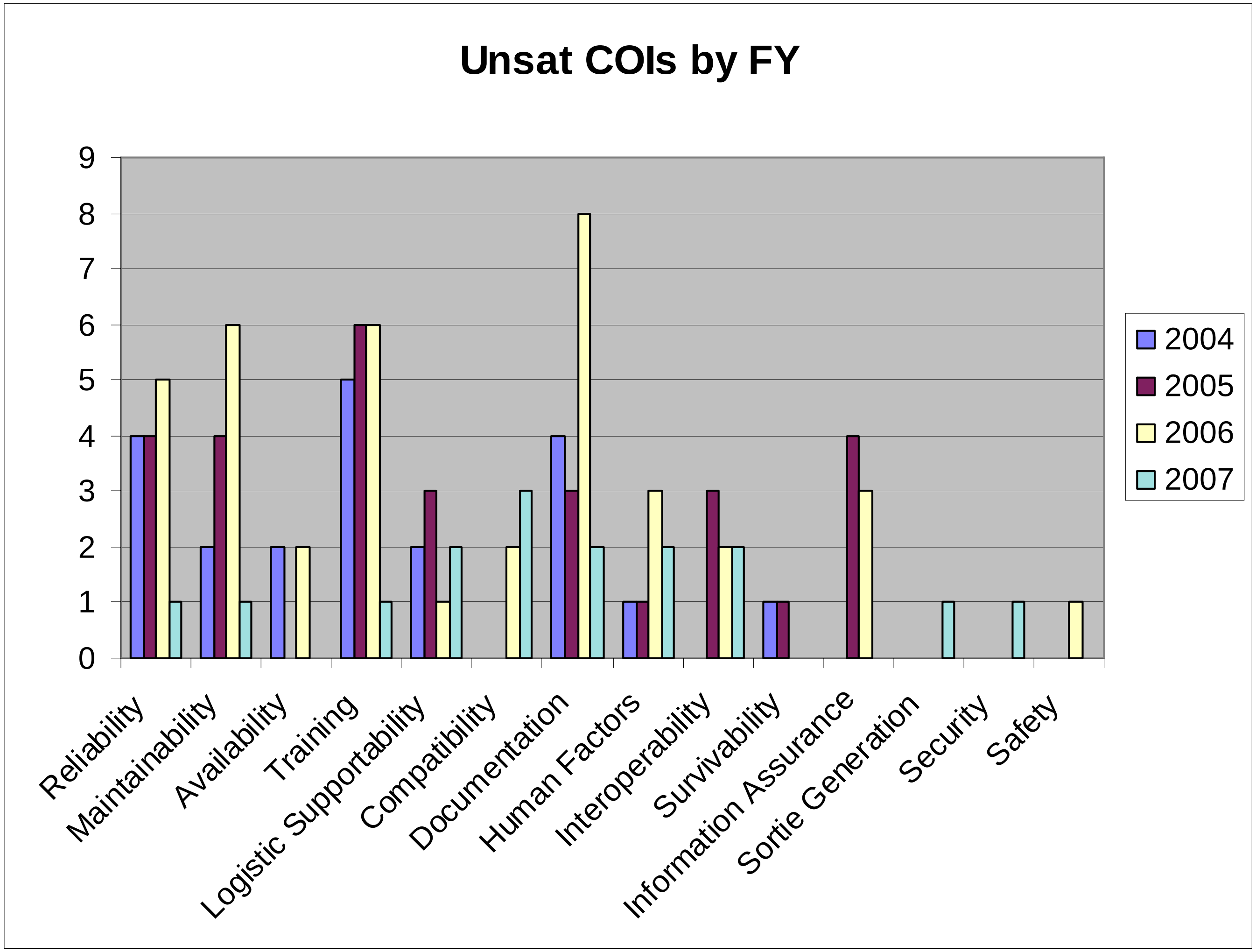
History

- Suitability is a long standing challenge – often the poor cousin of effectiveness
  - There have never been any “good old days”
- Aggregation of distinct but related disciplines
  - Reliability, Maintainability, Availability, Logistic Supportability
  - Compatibility, Interoperability
  - Documentation, Training,
  - Security, Information Assurance
  - Safety, Human Factors

How Are We Doing?



Trends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Availability
Training
Logistic Supportability
Compatibility
Documentation
Human Factors
Interoperability
Survivability
Information Assurance
Sortie Generation
Security
Safety

Technology

- Technological advances provide opportunities and challenges
  - Electronic technical manuals
  - Improved human-machine interfaces
  - Higher Order Languages & re-usable software
  - COTS/GOTS components
  - Open Architecture
  - Speed to market
  - Increasing complexity

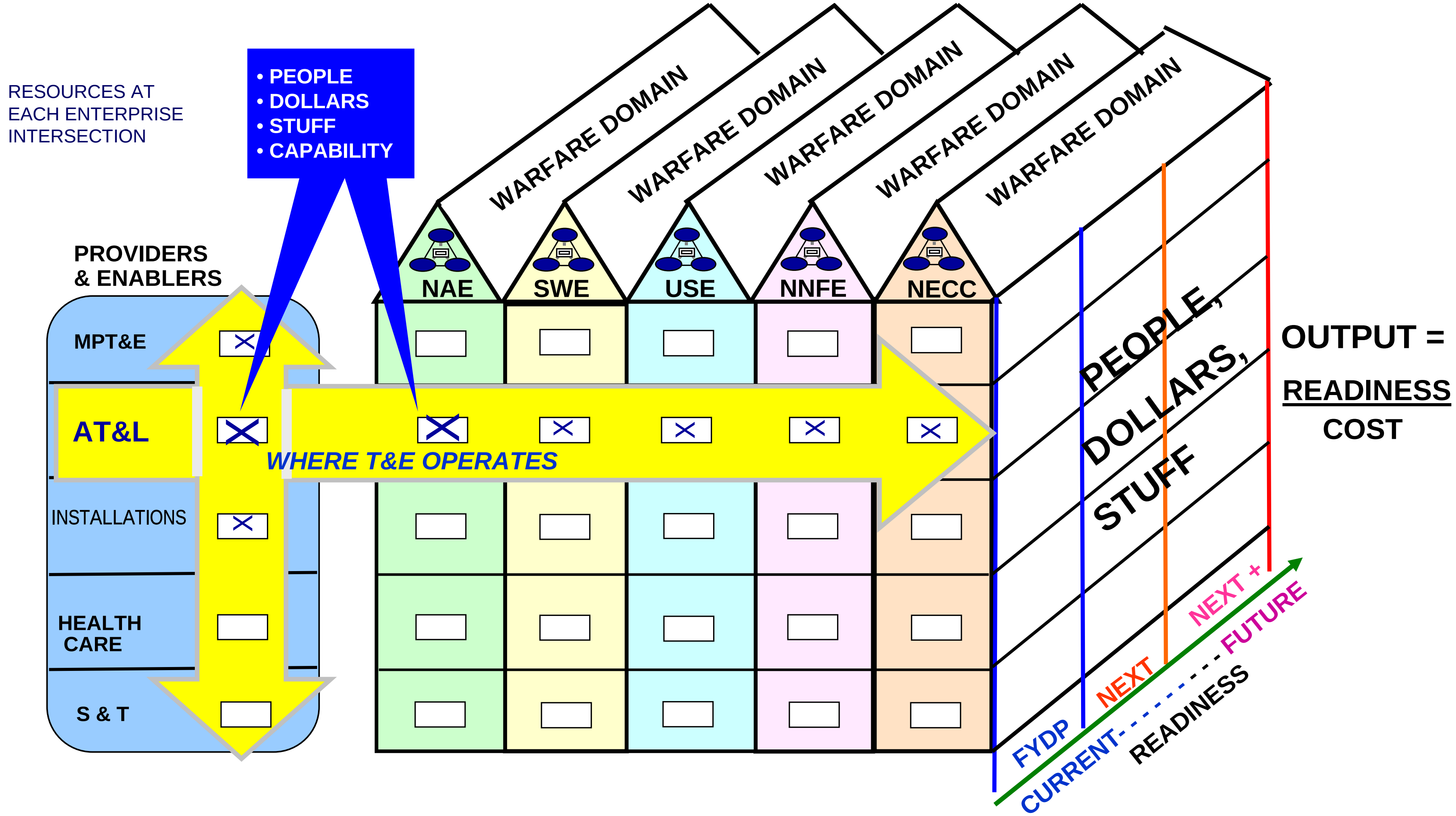
Cultural Issues

- Acquisition system favors successful demonstrations of technology vice a rigorous assessment of potential manufacturing challenges
- Early discovery is as likely to be penalized as rewarded
- Focus on delivering new capability without understanding that ownership costs may result in less overall warfighting capability

What can we do?

- Develop an enterprise approach that eliminates traditional distinctions between acquisition and life cycle costs.

OPERATING CONCEPT



DESIRED NAVY ENTERPRISE OUTPUT

✓ **READINESS OVER COST TODAY**
✓ **READINESS OVER COST TOMORROW**
✓ **READINESS OVER COST IN THE FUTURE**

Achieved Through Behavioral Model (Interdependent Concept of Operations):

- ***Navy Enterprise (Governance Board):***
  - *Senior Navy strategic decision forum focused on improving productivity for current and future readiness through integration of supported Warfighter Enterprises.*
- ***Warfighter Enterprises (Five Supported Teams; Led by Super TYCOMs):***
  - *Collaborative teams focused on delivering warfighting capability to Navy Components and Combatant Commanders; and increasing productivity across their Domain at reduced cost.*
- ***Providers/ Enablers (Supporting Elements; with Designated Leads):***
  - *Operate as providers/ enablers to manage value streams (people, dollars, and stuff), supporting TYCOM-led Warfighter Enterprises, with linked and common processes/ metrics.*
- ***Domain:*** **Dollars, people, & stuff associated with each Warfighter Enterprise.**
- ***Demand Signal:*** **Derived from the Warfighter Enterprises (I.e., Readiness required and no more).**
- ***Entitlements:*** **What's needed, when, how much, and no more.**
- ***Output:*** **Readiness over Cost.**

What can we do?

- Develop an enterprise approach that eliminates traditional distinctions between acquisition and life cycle costs.
- Increase early involvement of the OT community
  - Early involvement efforts have tended to focus on mission effectiveness
  - There have been notable successes in identifying risks to maintainability, compatibility and safety
- Make T&E a true element of systems engineering
  - Evaluators must provide timely feedback in a manner that does not place the program at risk
  - Developers must value inputs

Leverage Modeling & Simulation

- Exploit technological advances to develop high fidelity physics based models
  - Gain insights earlier in development
  - Assess performance in operationally realistic environments that cannot be replicated in actual test due to numbers of assets/security concerns (Self-defense test ship, Weapons Analysis Facility)
- Leverage industrial techniques to understand risk areas in the manufacturing processes
- Understand the limitations of the simulations employed particularly in areas such as compatibility and interoperability

Suitability translates directly into combat power

COMOPTEVFOR

- Focus on Suitability
  - Increase technical expertise to more rigorously assess RM&A
  - Leverage SYSCOM warrant holders for technical disciplines
- Expand early involvement to include designs for reliability as well as maintainability
- Seek feedback from Fleet to understand accuracy of Suitability predictions

Acquisition Community

- Focus on optimizing the Enterprise investment
  - Understand total ownership costs
  - Promote transparency
- Promote a systems engineering approach
  - Value early discovery
  - Identify areas of greatest risk to cost as well as greatest technical risks
- Resist temptation to allow below market buy-ins
- Metrics - move from consumption to output

BOEING

Washington, D. C. Operations

Phantom Works / IDS-AS

Business Development / Government Relations

Past, Present, & Future Trends in RM&A

March 14, 2007

23rd Annual T&E Conference

Ronald (Mutz) Mutzelburg

Past Trends

- Late 60s: AF Advanced Logistics Systems
- Mid 70s: AFLC Weapon System Budgeting
- 1976: AF Acquisition Logistics Division Formed
- Late 70s: RIW (Like PBL of Today)
- Early 80s: The AF Great Engine War
- Late 80s: LO Maintenance Challenge
- Late 80s: Air Staff GO Dedicated to RM&A
- 90s until Today: RM&A Treated Equally With Other Performance Parameters

Present Trends

- F-18 as an R&MA Trail Blazer
- JSF is also Focused on RM&A
- The Promise of UAVs
- Proving Operational Suitability Always a Challenge
- Must Meet Depot 50/50 Rule Vice CLS & PBL
- Antiquated IT

Future Trends

- Energy Efficiency
- Net Centric Logistics
- Enhanced Readiness Modeling & Analysis
- Health Management, Diagnostics, CBM+
- Government-Industry PBL Teaming
- Weapon System Reliability Equivalent to the Family Auto
- Color of Money Challenge

Sustainment T&E in Army Acquisition

March 13, 2007

NDIA, T&E Conference

ARMY TEST AND EVALUATION COMMAND

Outline

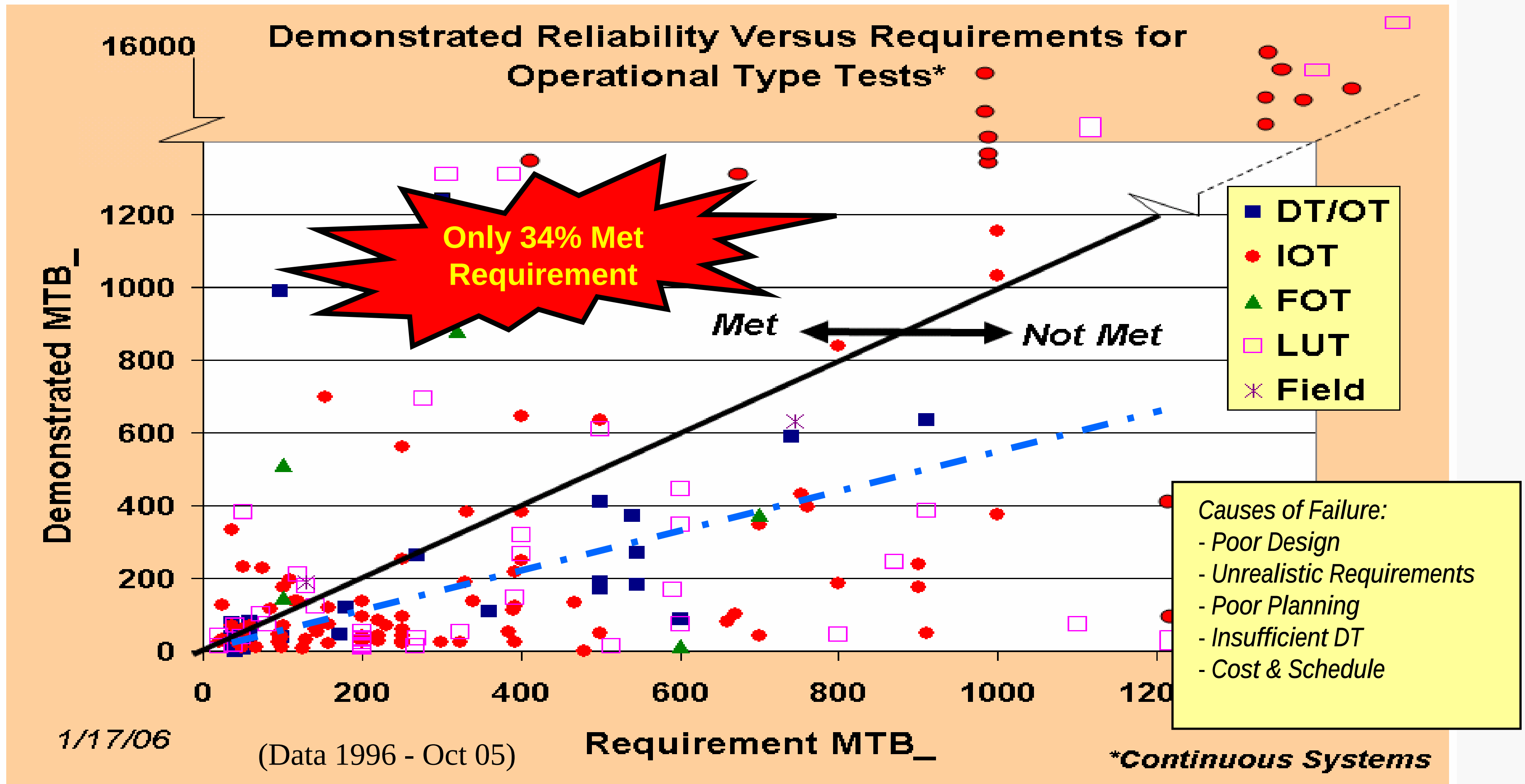
Sustainment in the ARMY

- The Need for Change
- Impacts
- Testing
- How To Enable Success
  - Reliability
  - Maintainability
  - Sustainability
  - Testing
  - Policy Changes
- Challenges
- ATEC Support of GWOT Fielding

ISSUE

Army Systems Consistently Fail To Achieve Reliability Requirements During Operational Testing!

The Need for Change



Amongst Systems Which Did Not Meet Reliability Requirements In OT 75% Of Them Failed To Achieve Half Of Their Requirement

Impacts

- **Affects Warfighter**
  - Mission Success
  - Ao & Force Effectiveness
  - Log Footprint
  - Safety & Soldier Confidence
- **Life Cycle Costs (LCC)**
  - Sustainment accounts for 60% LCC
  - Spares & Maintenance contribute to 90% of Sustainment Costs – Reliability is the driver.
  - Reliability impacts billions of $$$

Distribution of Life Cycle Costs
(Percentages)

Type System	R&D	Investment	O&S
Ground combat vehicles	5	35	60
Surface ships	<5	30-50	45-65
Jet fighters	5-10	25-50	40-70

Sources: Selected Acquisition Reports, VAMOSC systems

We need a process to improve Sustainability for Army Systems

Reliability Is Not Just About Testing

Why?

- **accelerated acquisitions & immature designs**
- **more complicated systems**
- **software intensive systems**
- **fielding of system of systems**

And

Increased emphasis on Sustainability

We have to do things differently …

Reliability Enablers
(Embedded in FCS Program)

Design In Reliability Early On

Physics of Failure (PoF)

➢ Early Design Influence through Physics- Based Modeling of Critical Component Designs
   • Model the root causes of Failure (Fatigue, Fracture, Corrosion & Wear)

Tangible benefits of PoF

Improved Ribbon Bridge

Sys. Req: 104,520 Crossings

PoF Usage
- **Avoided lengthy retest- saved $1-2M**
- **Supported Urgent Materiel Release**
- **IRB deployed**

****Army Materiel Systems Analysis Activity***

Reliability Enhancement Testing (RET)

➢ Used to Find Weak Areas of the Design and Correct them Before Production Begins

➢ Destructive test which incrementally increases environmental stresses to determine Failure Modes - Find Design Faults

Emphasize Early ID & Elimination of Failure Modes

Maintainability Enabler: The Pit Stop Philosophy
(Embedded in FCS Program)

Pit Stop Design is an approach for designing maintainability in military systems that is derived from auto racing. Emphasis is on simplicity of design to minimize downtime due to repair. Pit Stop Design is not designing to minimally meet a requirement, it is designing to win

Some Characteristics of the design approach are:

- Design component packaging minimizing weight and volume
- Modular design to allow commonality and upgrades
- Reduction of tools, with none being the goal
- Service by a single soldier, whether a 1st percentile female or a 99th percentile male, in MOPP IV or winter gear
- Handles and grip areas on components
- Simplicity of design minimizes maintenance training

Designs for Maintainability And Producibility

Planning, Tracking & Verification Reliability Use Case*

The R&M Case Is A Reasoned, Auditable Record To Document How Well A System Supports Requirement Realization. It Contains Evidence For R&M Achievement

<u>Evidence</u> includes 3 objectives:

1. Understanding the Requirements
2. Planning & Implementation necessary to satisfy requirements
3. Assurance that the requirements are being met

Forces Contractor to Plan for R&M Maturation; Develop Associated Tasks and Activities; and Provide <u>Evidence</u> Requirements Are Met

**Contract deliverable for each FCS vendor*

<u>Examples of Types of Evidence</u>

- ✓ Design M&S
- ✓ RAM Modeling, Component, subsystem, system testing
- ✓ Environmental Stress Analysis
- ✓ Structural Finite Element analysis
- ✓ Fatigue Analysis
- ✓ FMECA & Fault Tree Analysis
- ✓ Prognostics Assessments
- ✓ Rel. Enhancement Testing
- ✓ Pit Stop Engineering
- ✓ Software Reliability

What Needs to Be Done Differently: ILS Perspective

Conduct Smarter Logistics Demonstrations
- Implement Readiness Reviews prior to test conduct
- Make more operationally realistic

Apply Systems of Systems Approach To Sustainment Concepts
- Eliminates stove piping & reduces cost and logistics footprint

Incorporate Prognostics As It Matures
- Big potential for gains in operational availability

Apply Greater Use Of Sustainment Based M&S
- Supports more accurate sustainment estimates

Implement the Common Logistics Operating Environment (CLOE)
- Enables real time visibility of sustainment requirements for fielded systems

Strive To Decrease Maintenance Burden And Expedite Repairs

Why Integrated System Testing?

- Technical/Developmental Testing Conducted
  - to find faults, implement corrective actions, and mature the design
  - to confirm technical capabilities/functionality and manufacturability.

ATEC Studies Indicate Failure To Meet RAM Requirements In DT Almost Always Results In Failure In OT

- Operational Testing Conducted
  - to provide info. on integration of the Soldier, the support system, training & doctrine, and materiel in an operational environment.
  - to confirm/demonstrate operational suitability requirements.

Need Earlier Testing With Operational Realism

The Costs Of Operational Testing And The Importance Of Correctly Deciding Whether To Proceed To Full Rate Production Makes It Important To Base Decisions On All Available Relevant Information!

RAM Operational Testing Concerns

- **Difficult to get sufficient sample in OT to address RAM**
  - **Cost, schedule, soldier availability, data collection on non-interference basis difficulties**
- **Leverage DT to address Reliability requirement compliance**
  - **Historical data indicates no difference in DT-OT reliability performance for: AV, CMBT. Vehicles, Automotive, AMMO, Soldier & Combat Support Items**
  - **OT does not have to be "sized" for RAM. Can provide info on induced operator/maintainer failure modes**
  - **For electronics, DT not a good predictor of OT Reliability performance**

Strive to make DT more "Operationally" relevant!

Requirements & Policy Changes

- Mandatory Sustainability KPP for all JROC programs along with two Key System Attributes (KSAs)
  - *KPP - Availability*
  - *KSA – Materiel Reliability*
  - *KSA – Lifecycle Ownership Costs*

  (TRADOC Reg. 71-20)

- DOTE has emphasized the Need for Change/Improvement in Reliability/Sustainability

- Type Classification-Standard and Full Materiel Release now required for FRP
  - *Sustainability & RAM requirements must be met*

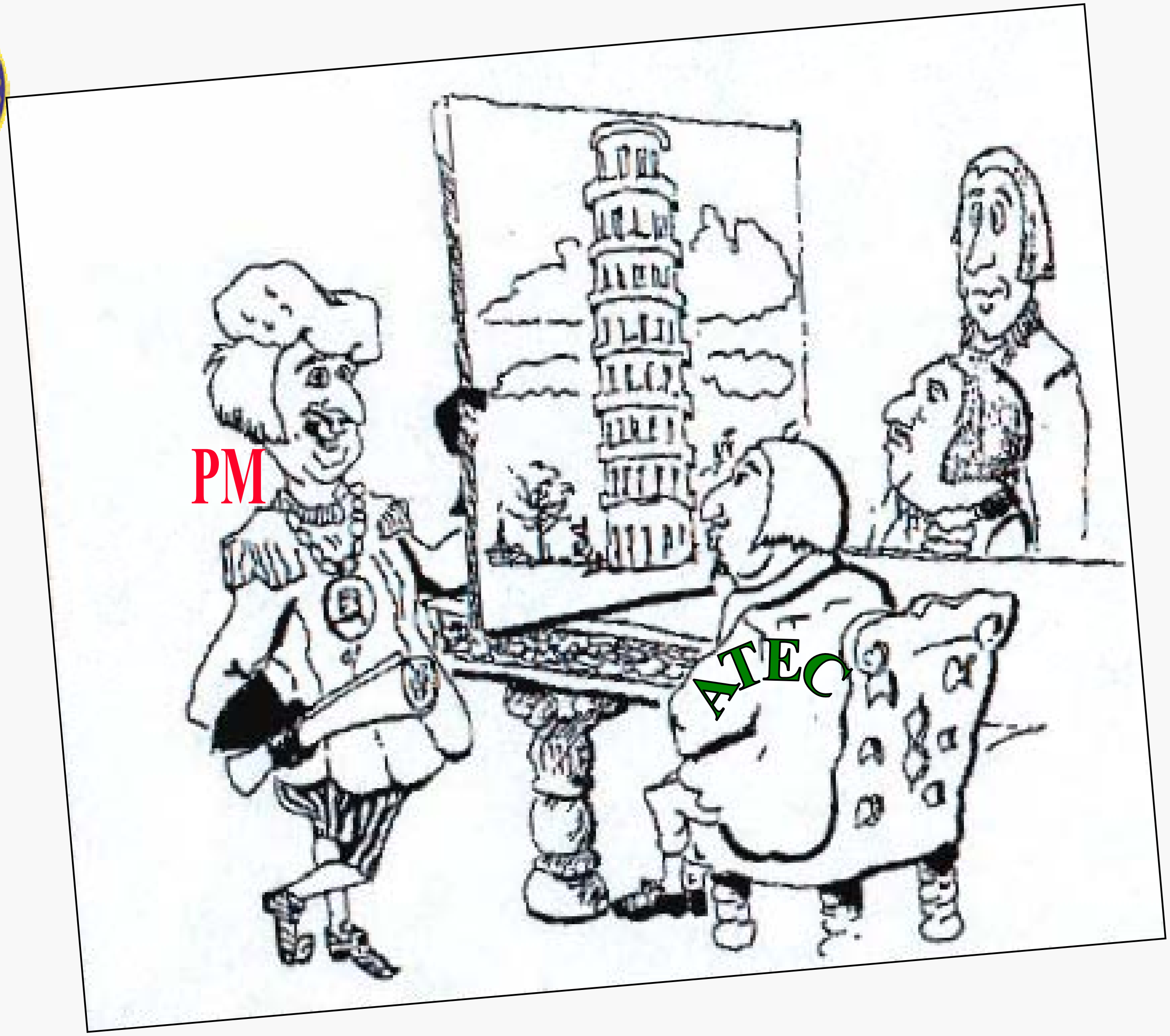
- Army T&E Acquisition Executive Initiative
  - *Establishment of Reliability Thresholds early in SDD phase*

Importance of Sustainability Supported by Key Policy Changes

Challenges

- Need To <u>Design</u> Reliability And Maintainability Up-Front – Minimize Log Footprint And Associated Costs
- Need To Force The Contractor To Plan For R&M Maturation And RAM Requirement Compliance
- Ensure System Of Systems Approach Is Applied To The Sustainability Concept
- Need To Better Utilize All Relevant Data In Assessing RAM And Sustainability
  - Benefit through early testing with operational realism
  - Integration of developmental and operational testing
  - Better use of Modeling and Simulation to address Sustainability

The Incorporation of High Levels Of RAM/Sustainability In Our Systems Must Be Enabled Through Aggressive Up-Front Design, Realistic Testing, And Policies Which Support These Practices



" We've already run this through our Abacus model and we can save 900 Lira by not taking soil tests."

Direct Support to GWOT by ATEC

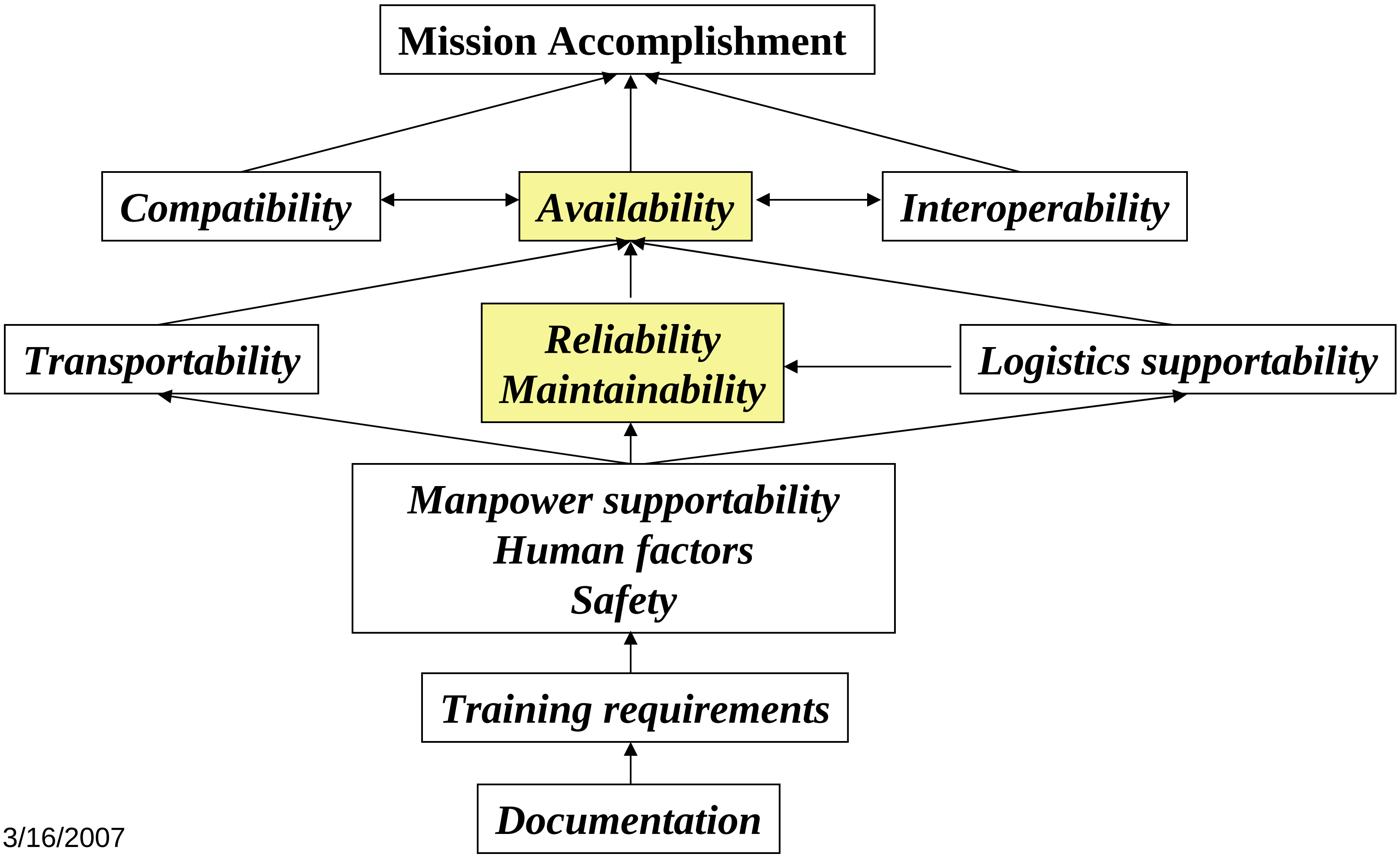
- Detailed Brief by Brian Simmons (AEC Director) on Thursday
- Normal Test Process Did Not Meet Urgency Timeline
- Soldiers and Commanders Still Need to Know:
  - Does It Work?
  - How Do I Know?
- “Leaned” T&E Processes
  - SER → Capabilities and Limitations Report
- Long Term Reliability Remains a Concern

Suitability Assessment in Capabilities-Based T&E

Vincent P. Roske, Jr.
Institute for Defense Analyses

3/16/2007

Suitability
Affecting Mission Accomplishment



Guidance Relating to DOD T&E

- **Strategic Planning Guidance (SPG) 2006-2011:**
  - "**Development and fielding of joint force capabilities requires adequate, realistic test and evaluation in a joint operational context. To do this the Department will provide new testing capabilities and institutionalize the evaluation of joint system effectiveness as part of new Capability Based processes.**"

- ***Recommendation from SPG tasked Report, "Testing in Joint Environments (TIJE) Roadmap"*** *:*
  - ***"Establish a common, TASK-based language derived from UJTLs for use in Concept development, functional analyses, JCIDS capabilities, acquisition, T&E, training and experimentation and mandate its use in all JCIDS documents.***

What is Needed? How Might it Work?

A Common, Task-based Language Definitions of "Capability"

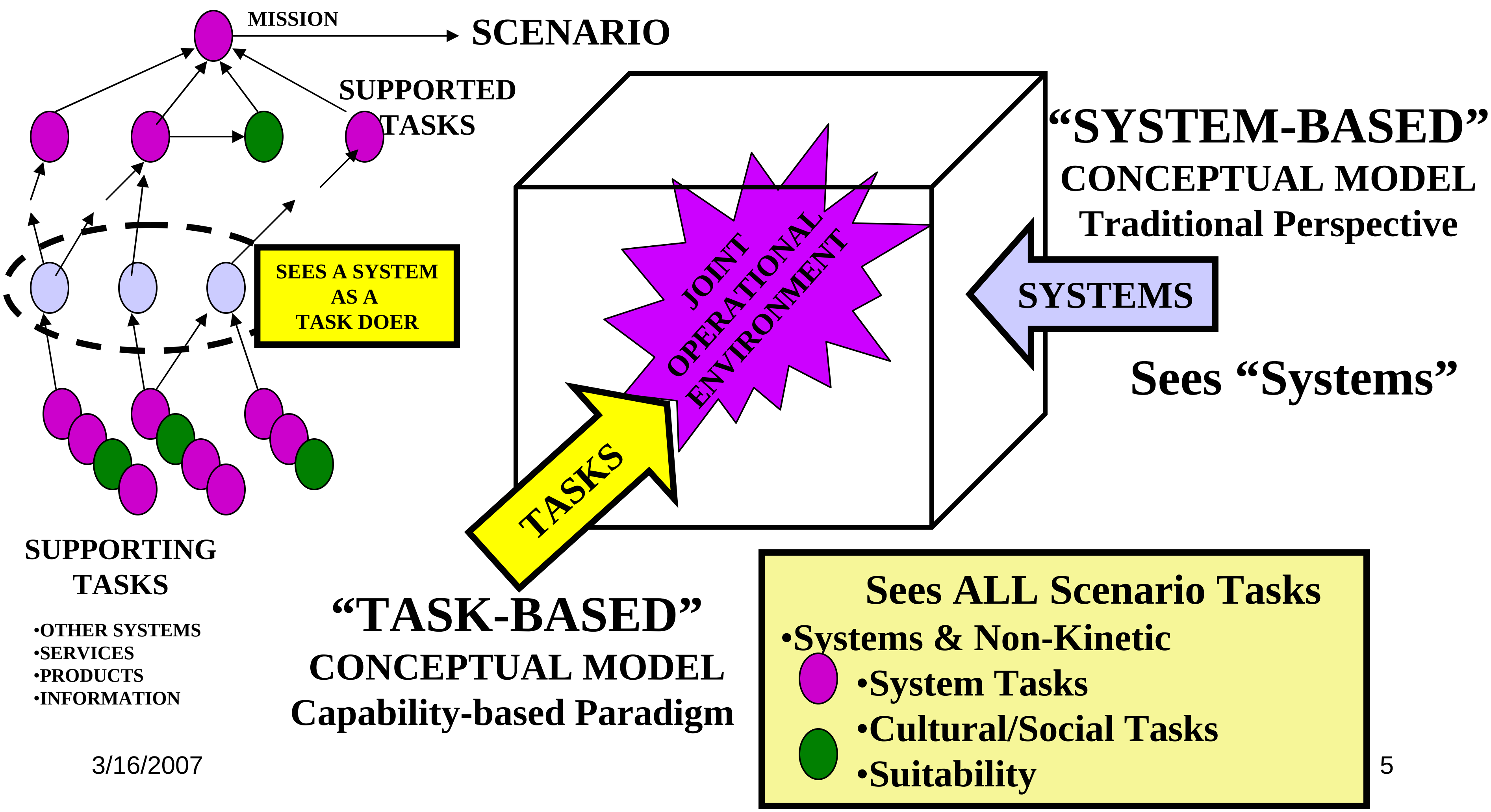
- **<u>CJCSI 3170.01 11 May 2005, JCIDS</u>**
  *The ability to achieve a desired effect **<u>under specified standards and conditions</u>** through combinations of means and ways **<u>to perform a set of Tasks</u>**.*

- **<u>Government of New Zealand, Pub 001, Corporate Statement of Intent(2004-2007), Appendix 5, Glossary</u>** ***SUITABILITY***
  *The appropriate **<u>combination of competent people, knowledge, money, technology, physical assets, systems and structures</u>** necessary **to <u>deliver a specified level of performance</u>** in pursuit of the organization's objectives, now and/or in the future.*

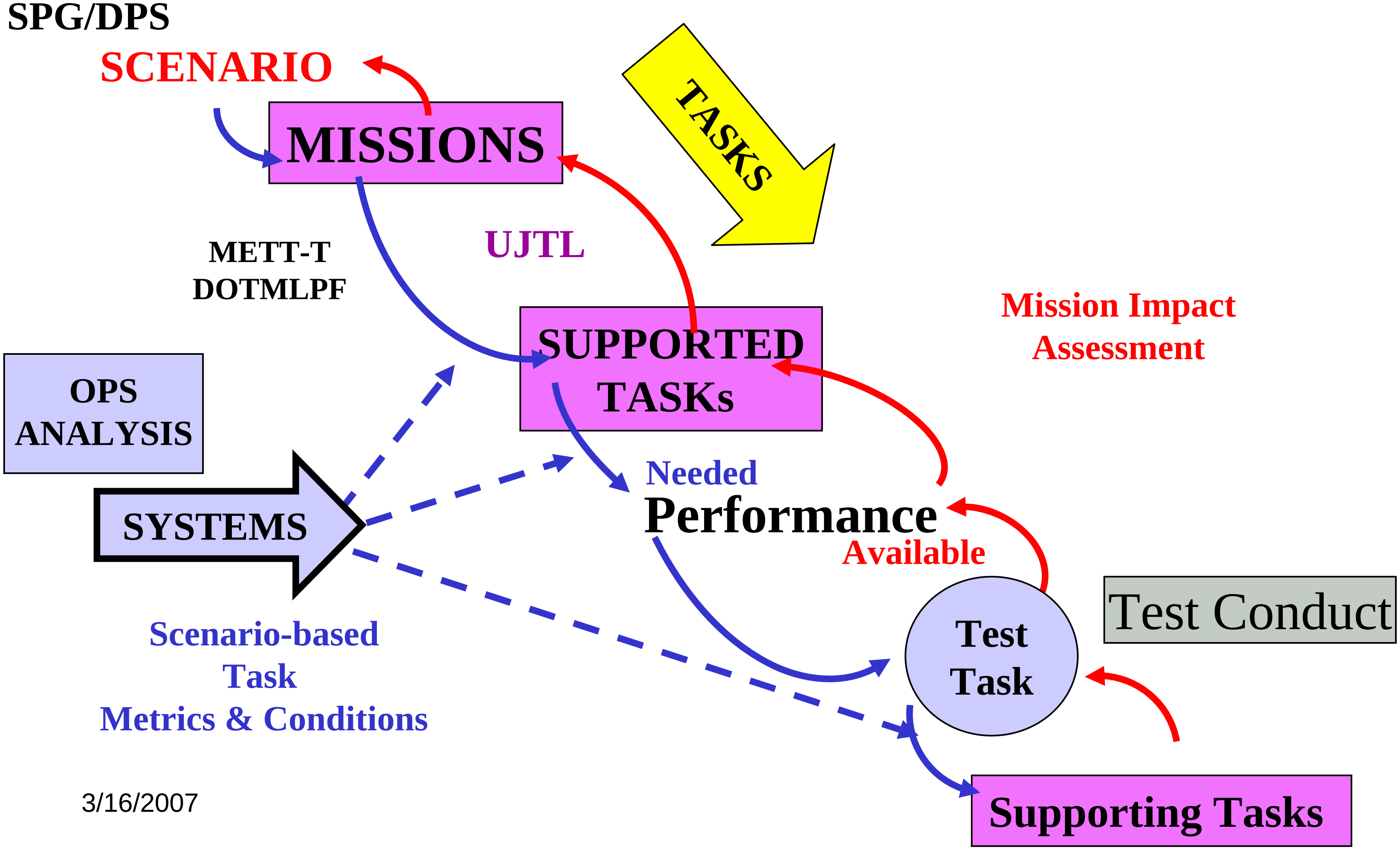
- A Capability is a Task performed to Mission derived Conditions and Standards

Capability-Based = Task-Based

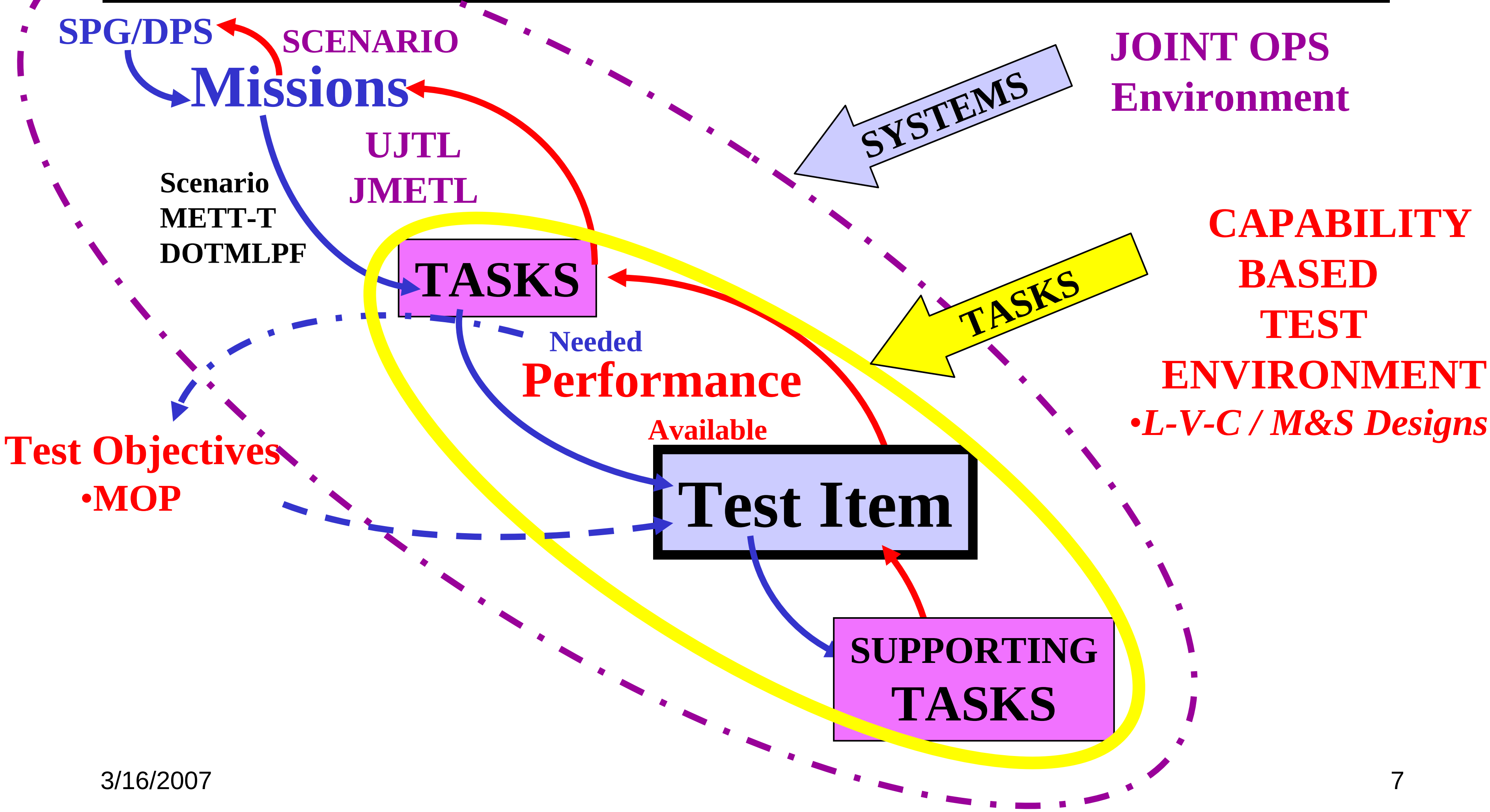
TWO Conceptual Models of the Joint Operating Environment



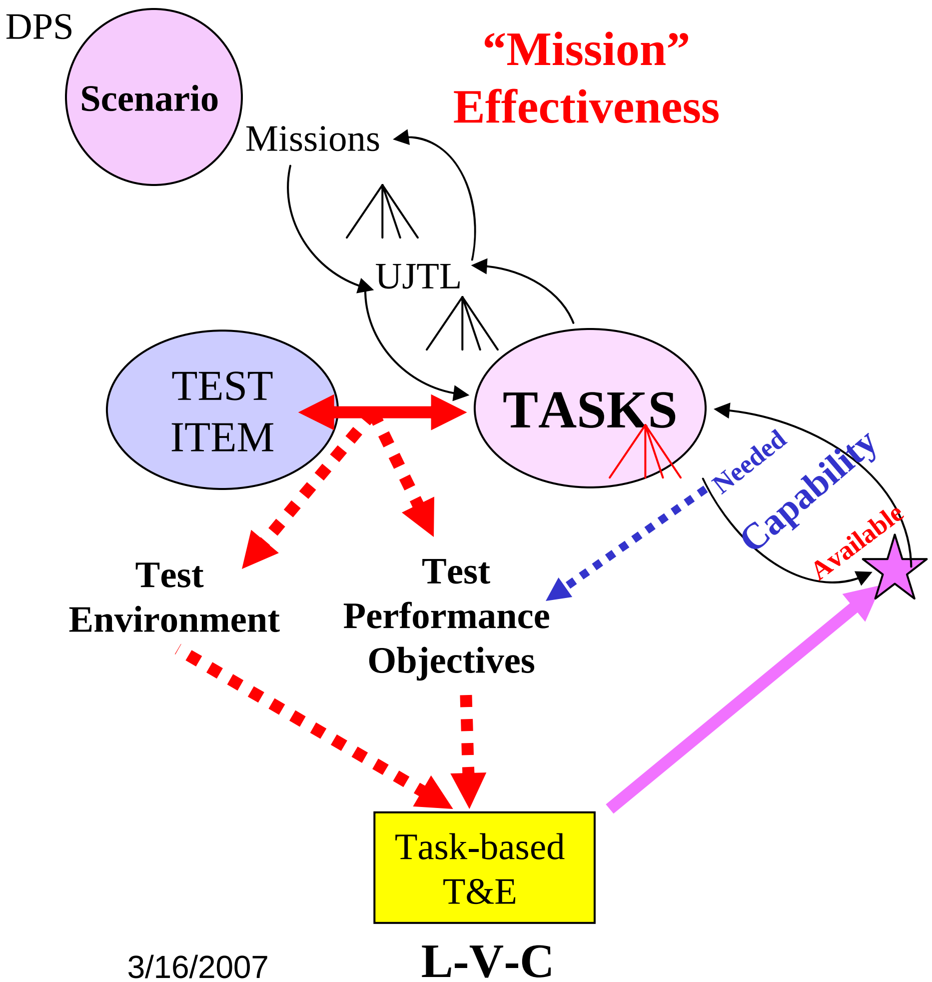
Joint Operational Environment
Two Conceptual Models

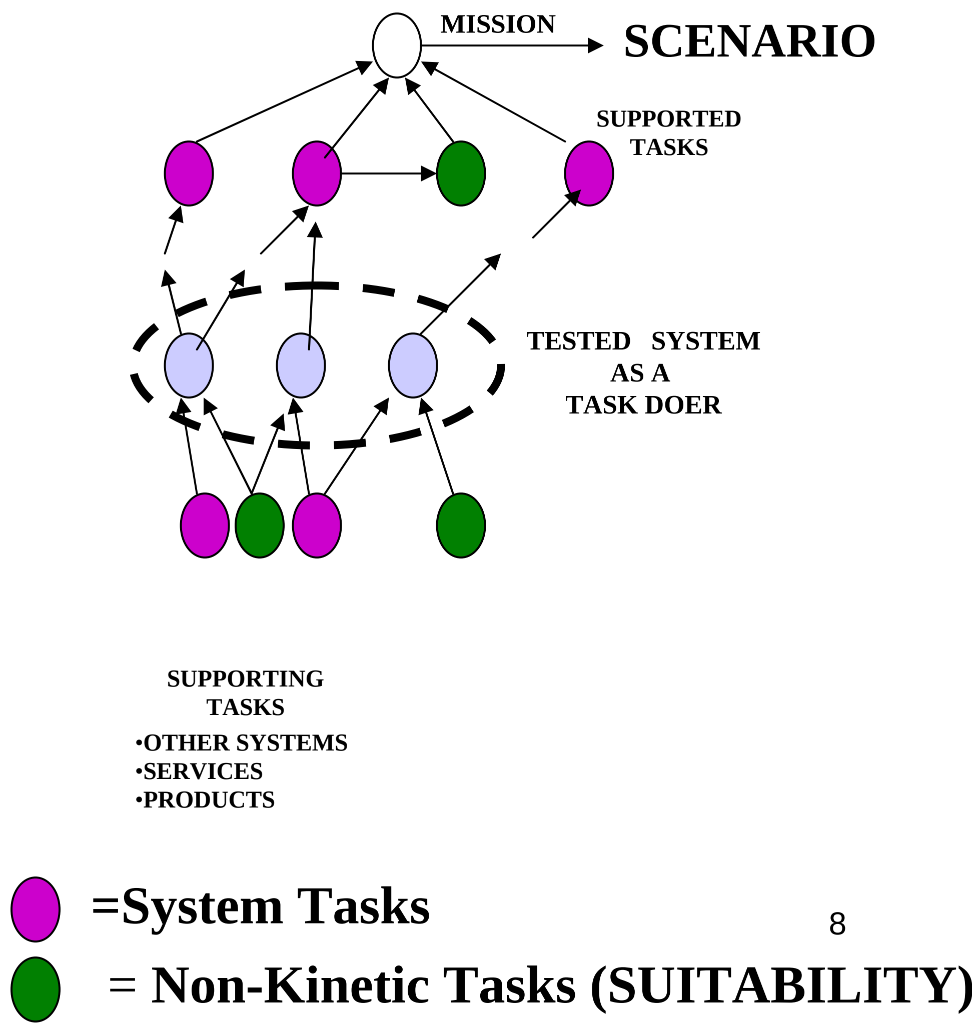


Task Based Test Environments
LVC Design Efficiency

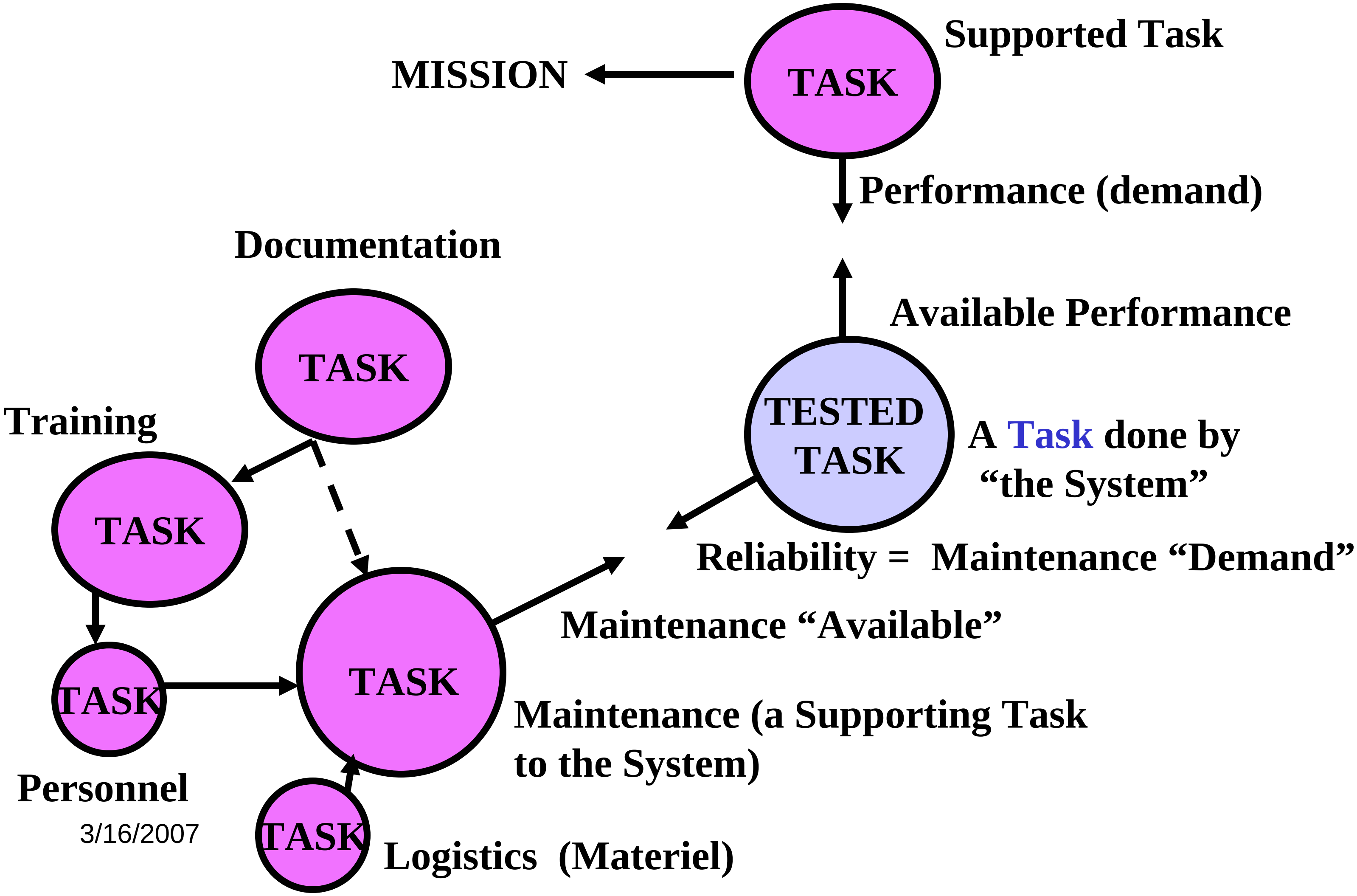


Capability-based T&E
Test Design & Assessment

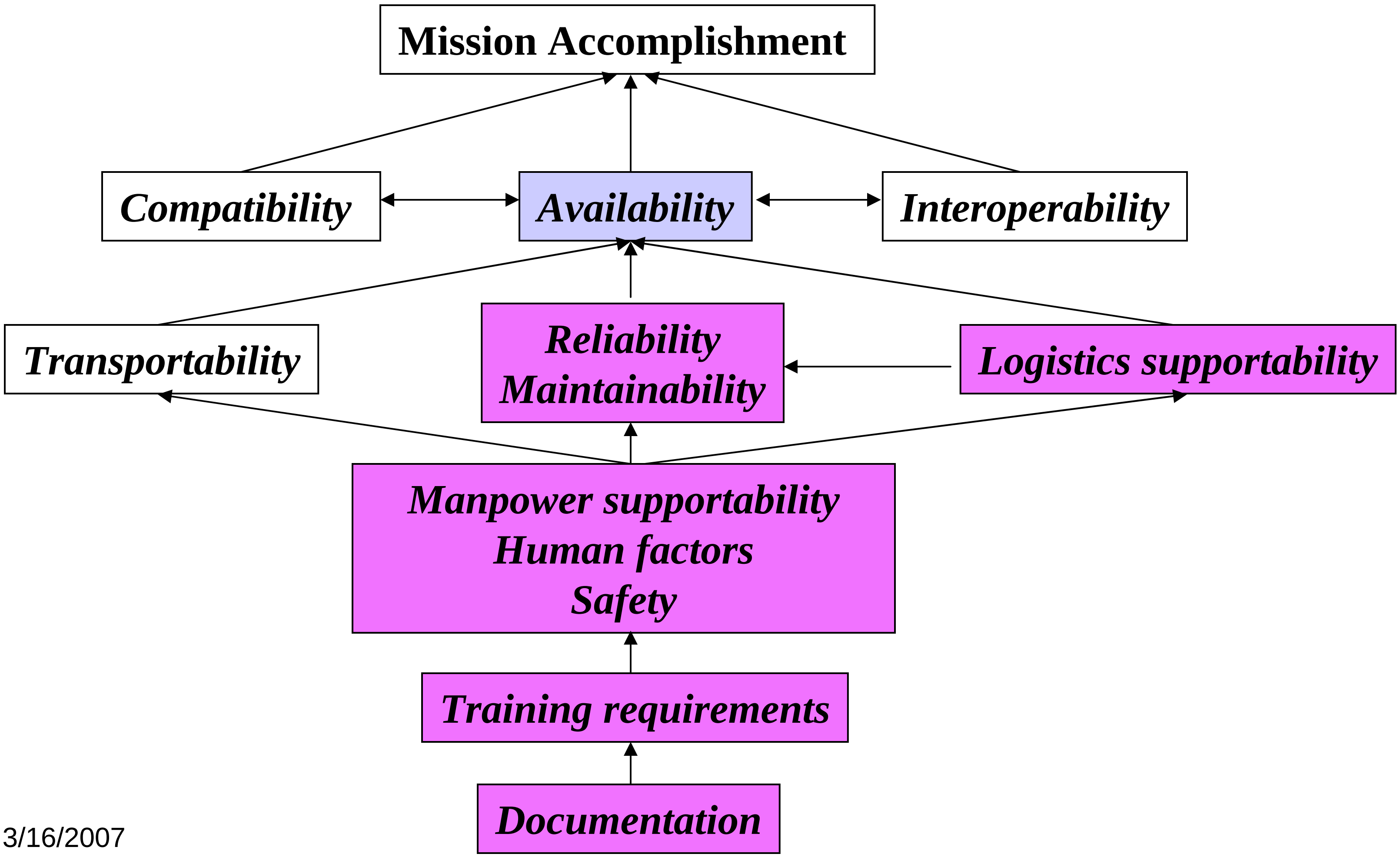




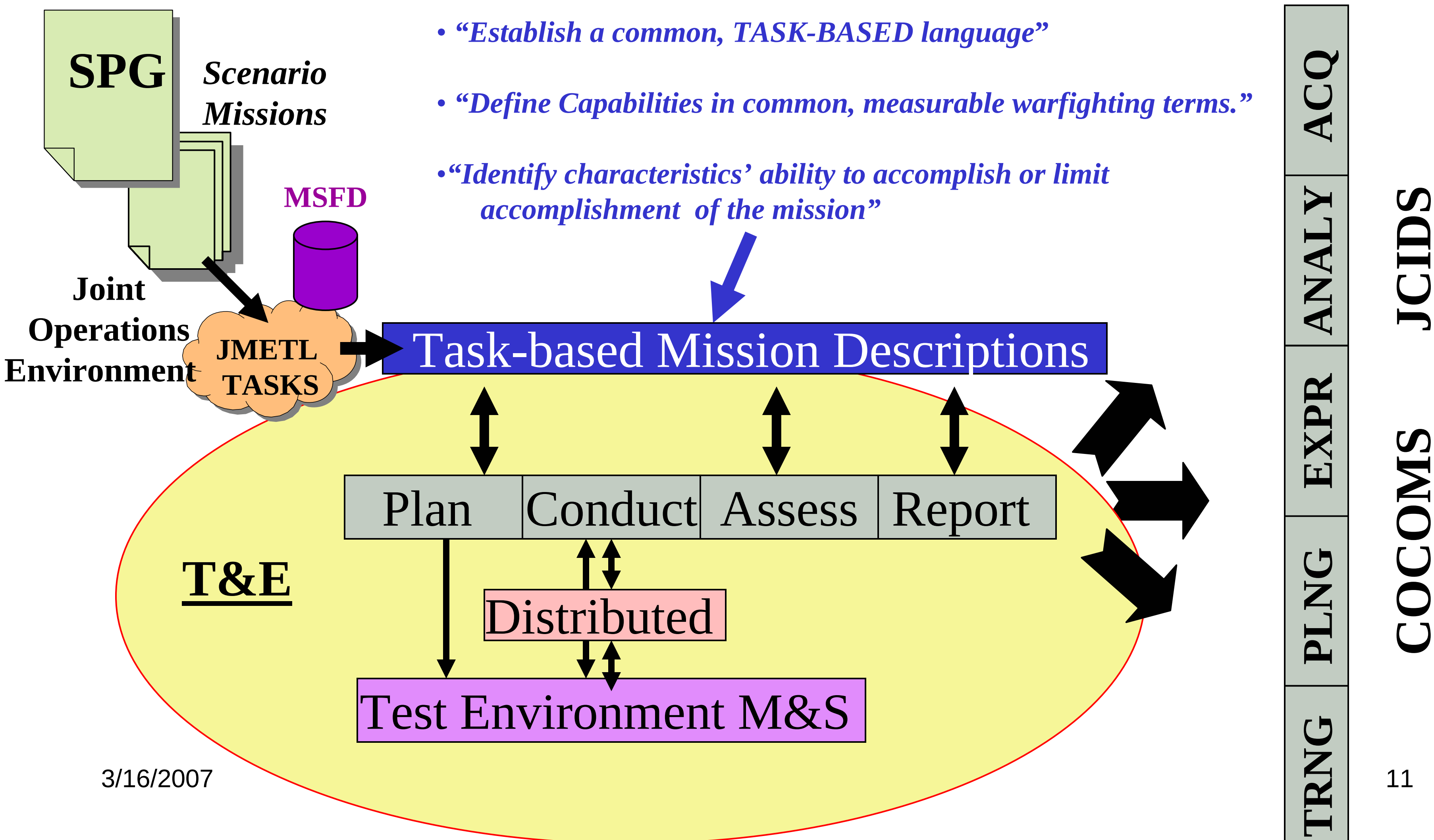
Capability-based Suitability Testing
"Suitability" Components



Suitability
Affecting Mission Accomplishment

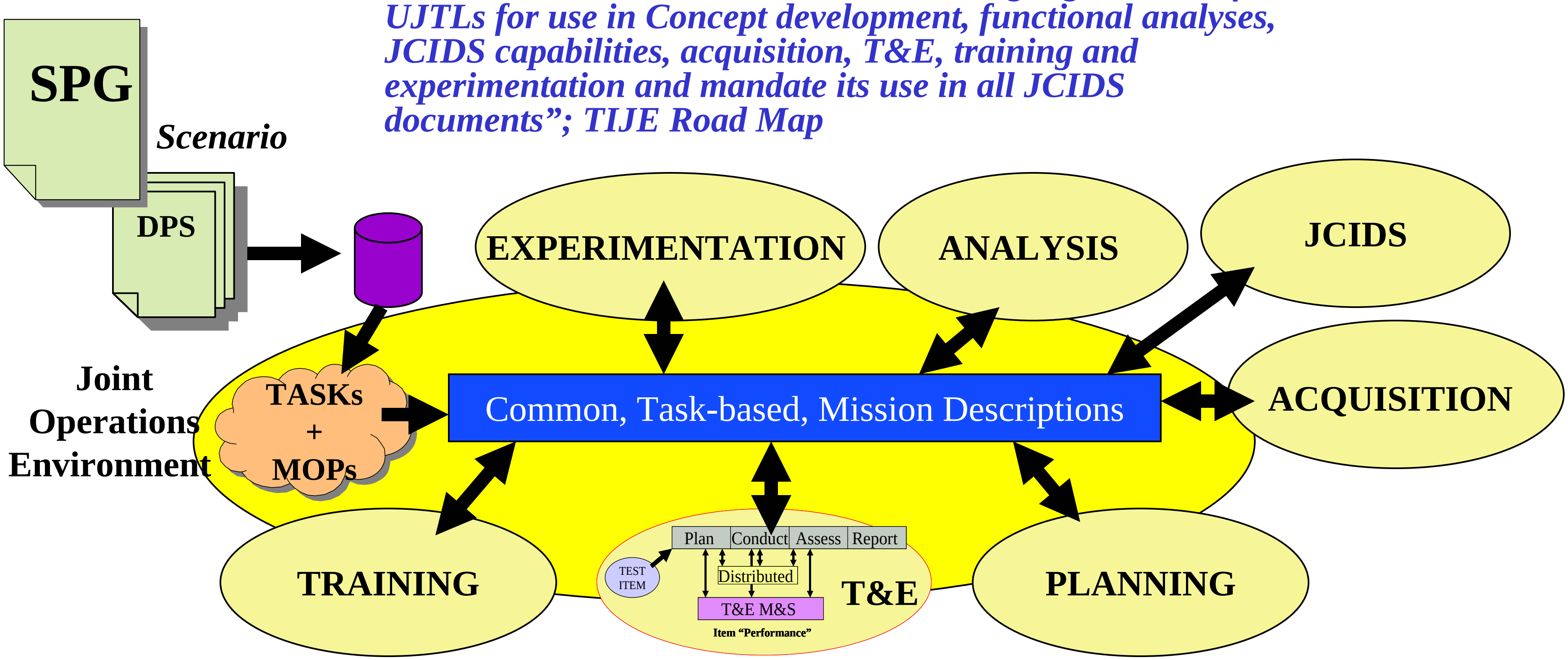


Capability Assessment T&E Process Implementation Approach



Common and Cross Cutting Capability-based Conceptual Model

"Establish a common, TASK-BASED Language, derived from UJTLs for use in Concept development, functional analyses, JCIDS capabilities, acquisition, T&E, training and experimentation and mandate its use in all JCIDS documents"; TIJE Road Map



Capability-based Suitability Testing
SUMMARY

- Task-based Conceptual Model of the Joint Operational Environment provides:
  - A comprehensive perspective on ALL activities in the Joint Operating Environment.
  - A useful paradigm for efficient & effective testing and assessment of system Suitability relative to Mission Accomplishment.

- Task-based Conceptual Models are increasingly important to DOD decision making
  - Address today's warfare processes more comprehensively than Systems-based paradigms.
  - Basis for an increasing number of DOD Assessment processes

- System-based Conceptual Models are still needed to inform on MOP for Tasks at the Strategic, Operational and Tactical Level.
  - An enduring role for traditional systems analysis and M&S

BACKUP SLIDES

A Common, Task-based Language
Task Performance Standards

CJCSM 3500.04c, 1 July 2002

- **The standard for a joint task is set within the framework of the joint force commander's mission and in the context of the conditions**, either most likely or worst case, that are linked to those missions**.** Thus, **the standard(s) for a joint task can only be set when:**
  - **(1) the mission analysis is complete**
  - **(2) the conditions affecting the task have been identified and described, and**
  - **(3) measures and criteria have been selected that reflect the task contribution to mission accomplishment.**

  This means that standards are tied to missions. That is, just because a joint task has a particular standard on one mission does not mean that the same standard will apply to other missions.

To become expressions of "Capability"
UJTLS require specification of scenario-based conditions and standards

CAPABILITY
DOTMLPF, Scenarios, Missions, Effects and Tasks

CONTEXT / RULES

- Strategy
- CONOPS
- METT-T
- Systems Characteristics
- TTP

Doctrine
Organization
Training
Leadership

MATERIEL

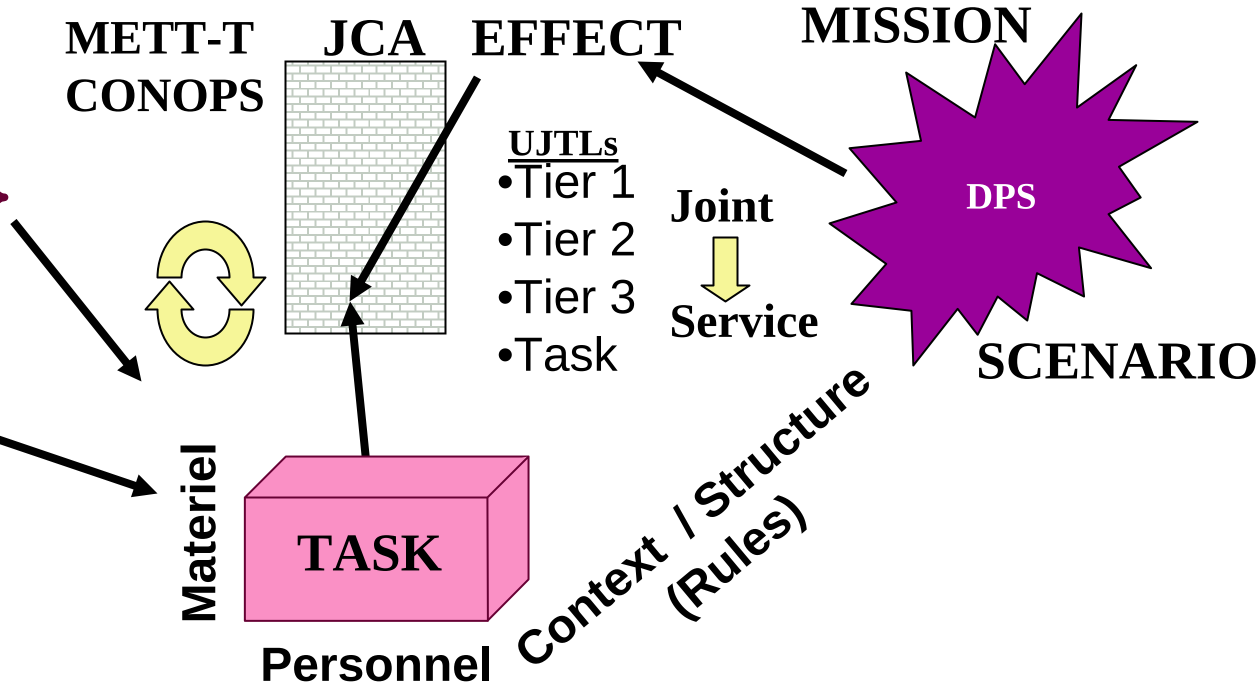
- Systems
- Supplies
- Equipment
- Ammo
- Bases
- Food
- Fuels
- INFO

etc

Materiel
Facilities

PERSONNEL

Personnel

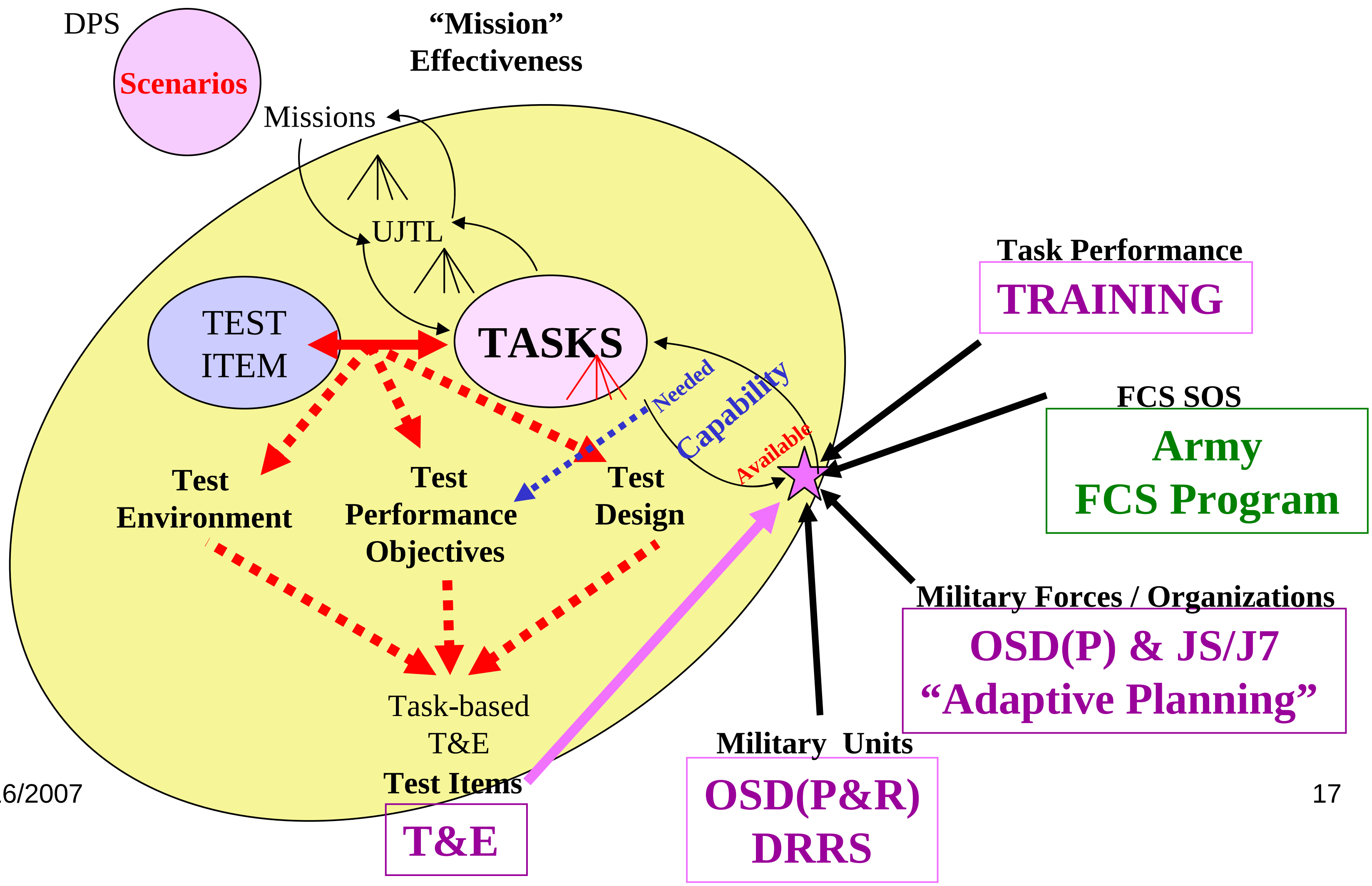


Capability => A **Task** performed to a **Standard**

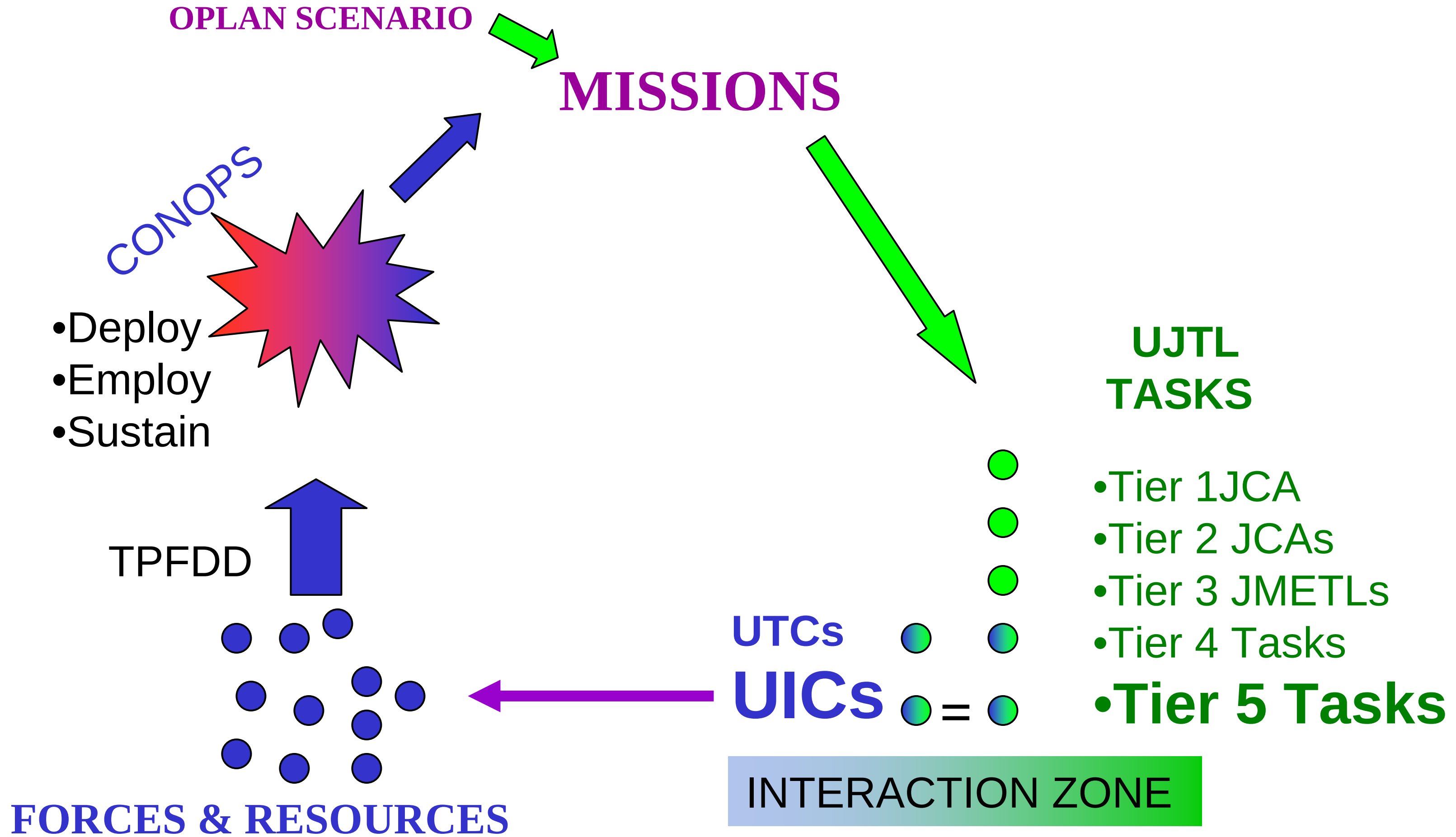
SCENARIOS & MISSIONS → EFFECTS

DOTMLPF → TASKS

Capability-based T&E
Other "Capability-based" Processes



Task-based Adaptive Planning Example



UIC “Capabilities = Tier 5 Capability Tasks

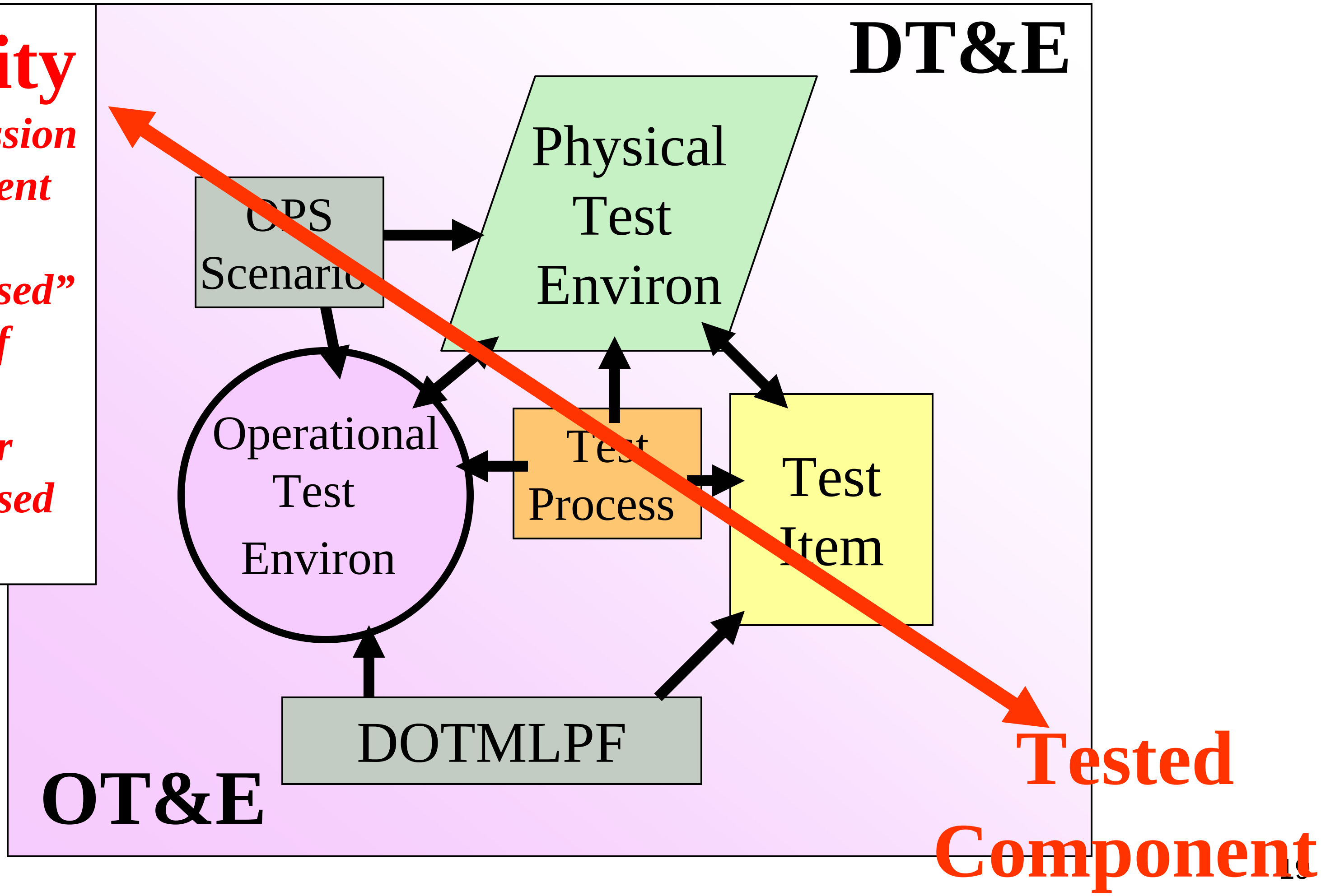
Capability-based T&E
Task-based T&E

Capability

•Related to Mission Accomplishment

•A "Tasked Based" Expression of Performance

•Useful to other Capability Based Communities



The Costs of Unsuitability and Benefits of Building in Reliability, Availability and Maintainability

Dr. Ernest Seglie,

Science Advisor, DOT&E

Ernest.Seglie@osd.mil

DoD IOT&E Results FY 2001 - 2003

Program	Service	ACAT	IOT&E Result		Reason
FY 2001					
F-15 TEWS	USAF	II	Effective	Not Suitable	Reliability, Maintainability, Availability
V-22 Osprey	Navy	1D	Effective	Not Suitable	Reliability, Availability, Maintainability (RAM), Human Factors, BIT
Joint Direct Attack Munitions (JDAM)	USAF	1C	Effective only with legacy fuses	Not Suitable	Integration with delivery platforms
M2A3 Bradley Fighting Vehicle	Army	1D	Effective	Suitable	
FY 2002					
Joint Primary Aircraft Training System (JPATS)	USAF	1C	Effective with deficiencies	Not Suitable	RAM, Safety, Human Factors
Cooperative Engagement Capability (CEC)	Navy	1D	Effective	Suitable	
Multiple Rocket Launcher System (MLRS)	Army	1C	Effective	Suitable	
MH-60S	Navy	1C	Effective	Not Suitable	RAM, excessive administrative and logistic repair time impacted RAM
FY 2003					
B-1B Block E Mission Upgrade Program	USAF	1D	Effective	Not Suitable	16% decrease in weapons release rate, reduction in accuracy of Mark 82 low drag weapons, 14% hit rate on moving targets
Sea wolf Nuclear Attack Submarine	Navy	1D	Effective	Suitable	Several requirement thresholds were not met but overall system effective and

DoD IOT&E Results FY 2004, 2005

Program	Service	ACAT	IOT&E Result		Reason
FY 2004					
Evolved Sea sparrow Missile	Navy	II	Effectiveness unresolved	Suitable	Testing was not adequate to determine effectiveness.
Stryker	Army	1D	Effective	Suitable	
Advanced SEAL Delivery System (ASDS)	Navy	1D	Effective with restrictions	Not suitable	Effective for short duration missions; not effective for all missions and profiles. Not suitable due to RAM.
Tactical Tomahawk	Navy	1C	Effective	Suitable	
Stryker Mortar Carrier-B (MC-B)	Army	1D	Effective	Not Suitable	RAM and safety concerns.
FY 2005					
CH-47F Block I	Army	1C	Effective	Not Suitable	RAM; communications system less suitable than CH-47D; did not meet Information Exchange Requirements for Block I.
F/A-22	USAF	1D	Effective	Not Suitable	RAM; needed more maintenance resources and spare parts; BIT
Joint Stand-Off Weapon-C	Navy	1C	Not Effective		Not effective against moderately hardened targets; mission planning time was excessive.
Guided-MLRS	Army	1C	Effective	Suitable	
High Mobility Attack Rocket System (HMARS)	Army	1C	Effective	Suitable	
V-22 Osprey	Navy	1D	Effective	Suitable	
EA-6B (ICAP III)	Navy	II	Effective	Suitable	

Air Force IOT&E Results

Program	Service	ACAT	IOT&E Result		Technical Reason
FY 2002					
F-15 TEWS	USAF	II	Effective	Not Suitable	RAM

SE Issues		
Issue	**SE Area**	**Rationale**
Requirements	Reasonableness Verification	RAM requirements not fully defined. BIT architecture and subsystem reliability not designed into system. BIT system was a major requirement for the system.
Program Planning	Allocation Sufficiency	Program focused mainly on Band 1.5 and did not address newer SAM systems; inadequate processing capability. Systemic analysis was not performed; might have captured systems integration problems and identified root causes for inadequate processing.
Acquisition Strategy	Acceptability	Program integrated Electronic Warfare (EW) systems with known reliability issues without performing a systemic analysis prior to design and integration.
Technical Process	Requirements Development System Integration, Test, and Verification	Program did not establish sound independent technical review processes. Software assurance and metrics not sufficiently established. Technical entrance and exit criteria not established for Developmental Test (DT) reviews and decisions.

Air Force IOT&E Results

Program	Service	ACAT	IOT&E Result		Technical Reason
FY 2002					
Joint Primary Aircraft Training System (JPATS)	USAF	1C	Effective with deficiencies	Not Suitable	RAM; safety; human factors.

SE Issues		
Issue	**SE Area**	**Rationale**
Requirements	Reasonableness Verification	No ORD Thresholds for R&M; program measured against objectives.
Program Planning	Allocation Sufficiency	Acquisition Reform – pilot program. Designed as COTS program. Multiple slips: evidence of a schedule-driven nature. Requirements not fully defined and understood.
Acquisition Strategy	Acceptability	Simple COTS approach. “Militarization” not fully defined or understood. Multiple slips: evidence of schedule-driven nature.
Technical Process	Requirements Development System Integration, Test, and Verification	COTS mentality led to simplistic test approach (e.g., FAA cert, Contractor Qual Test approach led to insufficient DT). Multiple slips. Requirements not tracked/traced to a verification and test plan.

Air Force IOT&E Results

Program	Service	ACAT	IOT&E Result		Reason
FY 2001					
Joint Direct Attack Munitions (JDAM)	USAF	1C	Effective only with legacy fuses	Not Suitable	Excessive mission planning times (Navy); system reliability; B-52 load times; container deficiencies (stacking, carrier ops).

SE Issues		
Issue	**SE Area**	**Rationale**
Requirements	Reasonableness; Design Synthesis Verification	B-52 load times not reflective of new complexity. Navy carrier operability (ruggedness) not adequately captured/defined. Significant focus on capability (accuracy). Reliability relied heavily on “warranty.”
Acquisition Strategy	Acceptability	Acquisition Reform – pilot program. Small program office. Capability-based contracting strategy; significant SE contracted as result. Significant focus on capability (accuracy). Reliability relied heavily on “warranty.”
Technical Process	System Integration, Test, and Verification	Unrealistic load times; test team load crew experience, training; test team mission planning experience/training.
Reducibility and Production Planning	Quality Control (Plant Layout)	Storage reliability. Significant failures related to minor quality control errors (i.e., missing sealant, kit packed with wrong covers, etc.).

Air Force IOT&E Results

Program	Service	ACAT	IOT&E Result		Reason
FY 2003					
B-1B Block E Msn Upgrade Program	USAF	1D	Not Effective	Suitable	16% decrease in weapons release rate; reduction in accuracy of Mark 82 low drag weapons; 14% hit rate on moving targets.

SE Issues		
Issue	**SE Area**	**Rationale**
Requirements	Reasonableness Verification	Validity of effectiveness measures, based on comparison with prior block (not as complex; different release mechanism; different weapons mix; key requirement met: weapons flexibility).
Acquisition Strategy	Acceptability; Sufficiency	Software conversion oversimplified. Significant program growth. “Program clarity” - funded program did not address numerous “known issues”; resulted in re-identification of numerous issues (situational awareness, controls and displays, reliability).
Technical Process	System Integration, Test, and Verification	T&E measures not well founded in ORD/CDD.

Air Force IOT&E Results

Program	Service	ACAT	IOT&E Result		Reason
FY 2003					
F-22	USAF	1D	Effective	Not Suitable	RAM; needed more maintenance resources and spare parts; BIT.

SE Issues		
Issue	**SE Area**	**Rationale**
Requirements	Reasonableness Verification	RAM requirements not fully defined for IOT&E but for a mature aircraft at 100K flight hours. RAM and BIT requirements not tracked/traced to a verification or test plan.
Acquisition Strategy	Acceptability; Sufficiency	Program did not recognize or fully fund RAM requirements and software development, especially the maintenance software portion. Labs were insufficiently supported with hardware-in-the-loop.
Technical Process	System Integration, Test, and Verification	Program did not establish entrance/exit criteria for software development, verification, validation, and test. Software not adequately tested and fixed in the lab prior to flight test. Mission technical issues overshadow RAM issues and RAM resources diverted to technical mission issues. Program did not have a sound risk assessment program.

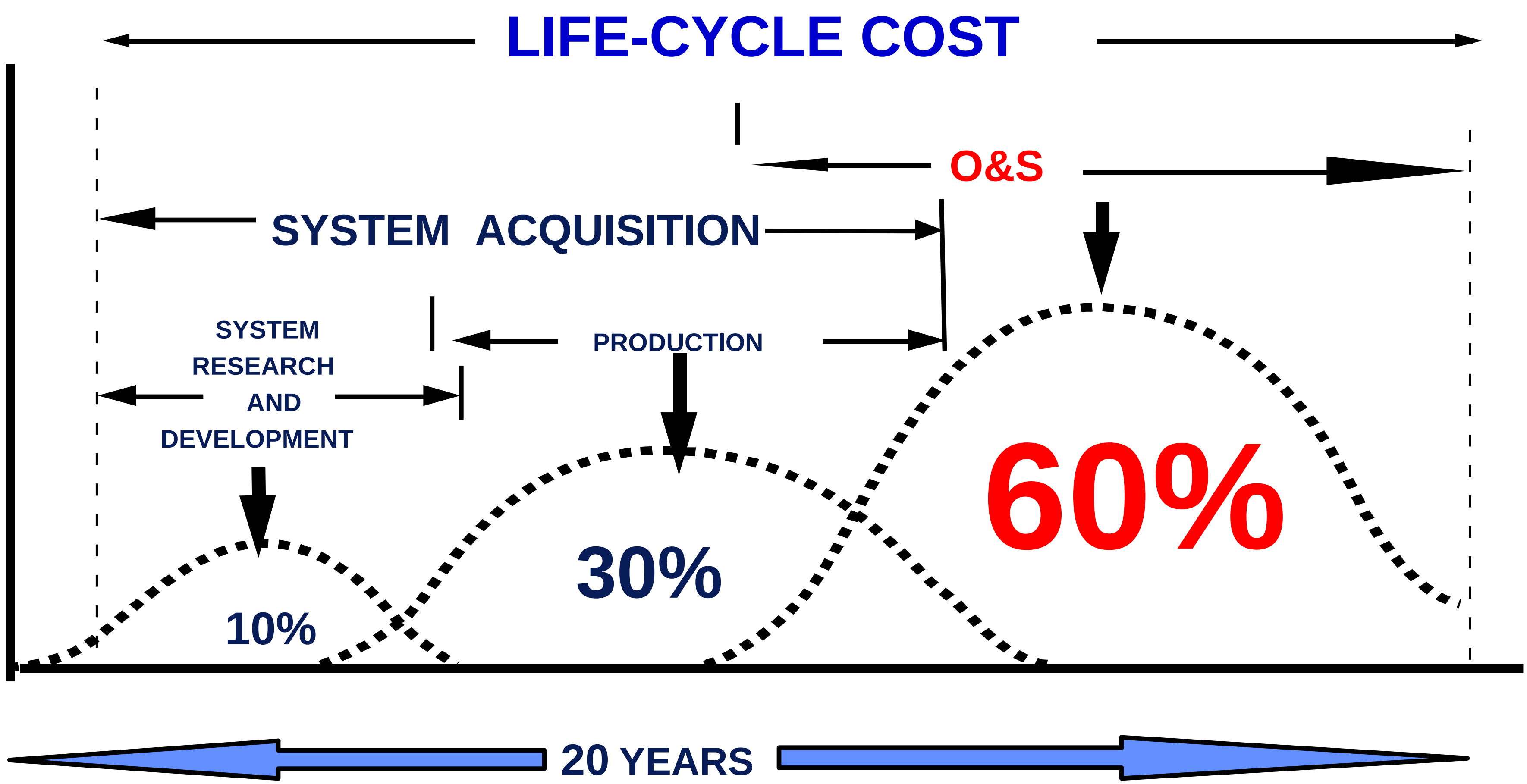
Additional Costs When a System is Judged Unsuitable (1)

- Some programs extended their SDD and added resources to redesign, reengineer and to retest till they became suitable
  - V-22 extended its SDD by five years and spent ~$1B to resolve its suitability issues. (It had a catastrophic failure in 2000)
  - C-17 is likely to be another interesting case.
- When failure in OT&E delays the full production and the fielding of a new system, it may require extra cost to operate and support, and in some cases, even Service Life Extension Program (SLEP) on legacy systems.

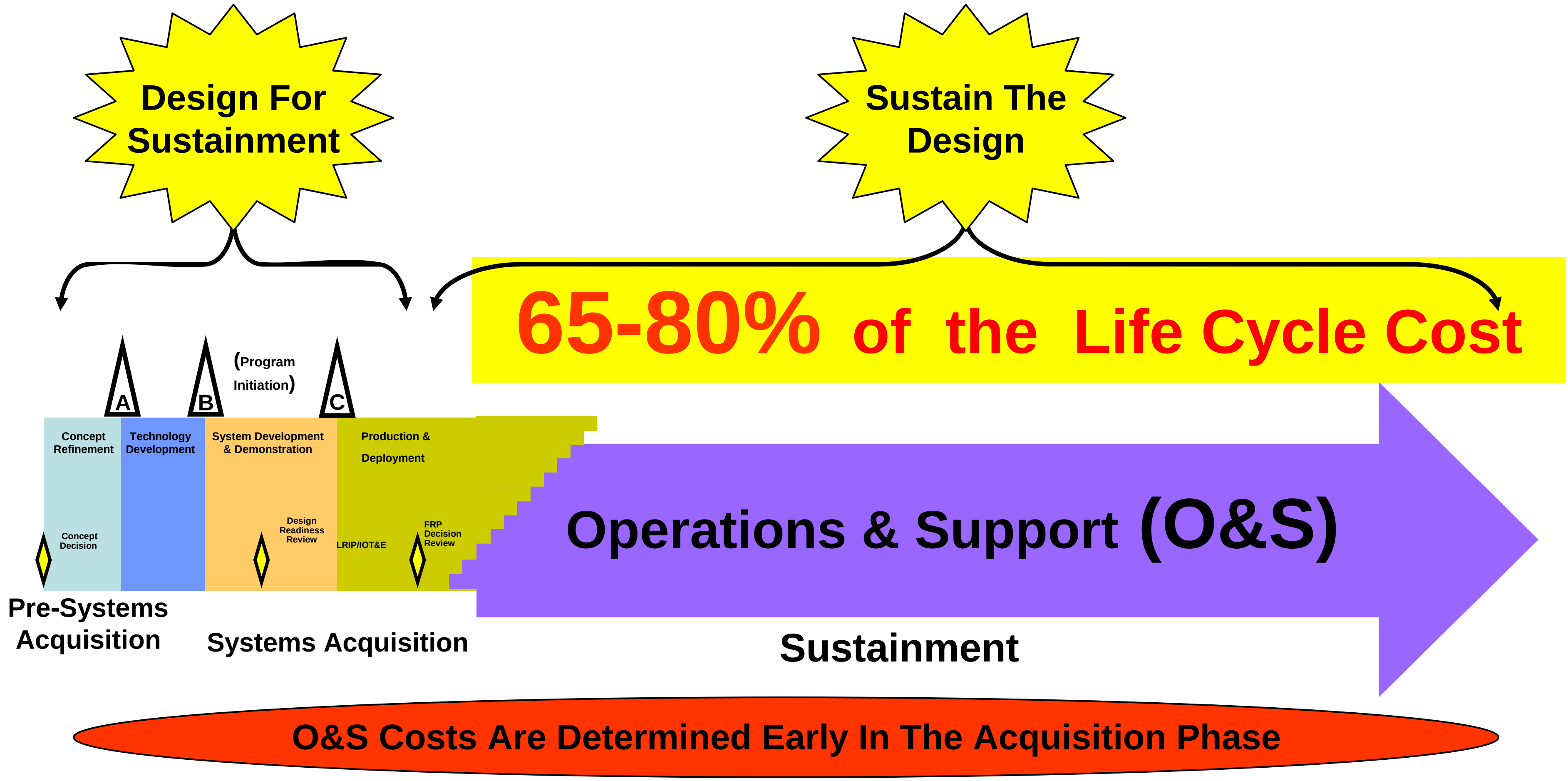
Additional Costs When a System is Judged Unsuitable (2)

- Some programs were granted FRP and delayed RAM remedial actions as Block Upgrades
  - Approach requires additional cost for RDT&E and retrofit. It is also more expensive to maintain and support several different configurations than one.
  - It turns to a spiral development approach.
  - Identify related RAM development and retrofit costs
  - Estimate additional operating and support costs for extra configurations
- Some programs are fielded with known RAM shortcomings
  - Extra costs for repair and maintenance or contractor logistic support when fielded at insufficient RAM level
  - Possible cost to procure and operate additional units to compensate for low availability to meet desired sortie rates or ton-mile capacity

LCC Distribution



Life Cycle Management



Four Causes

- No requirements
- Lack of incentives
- Attention elsewhere
- Poor Systems Engineering

JROC Memo: **17 Aug 2006**

"MATERIEL AVAILABILITY" KPP for all MDAPs and Select ACAT II and III

(KSAs):

A. Materiel Reliability KSA

B. Ownership Costs KSA

JROC Approved Mandatory Sustainment KPP and KSAs*

- **Single KPP:**
  - **Materiel Availability** $\left(= \frac{\text{Number of End Items Operational}}{\text{Total Population of End Items}}\right)$
- **Mandatory KSAs:**
  - **Materiel Reliability** (MTBF)$\left(= \frac{\text{Total Operating Hours}}{\text{Total Number of Failures}}\right)$
  - **Ownership Cost** (O&S costs associated w/materiel readiness)
- **Ownership Cost provides balance; solutions cannot be availability and reliability "at any cost."**

***JROC Approval Letter JROCM 161-06 Signed 17 Aug 06;**
Revised CJCS 3170 will put into Policy

Return on Investment

Estimate O&S and Initial Spares of Different F-22 MTBMs
(Constant 2006 $B)

Reliability Level at Maturity		MTBM in Hours (1)	O&S & Initial Spares (2)	Life Cycle Cost Difference (3)
FOT&E Actual	(1a)	**0.65**	**$ 42B**	**$ 7B**
IOT&E Actual with Historical Growth	(1b)	**0.83**	**$ 40B**	**$ 5B**
Air Force Program Reliability Projection	(1c)	**1.50**	**$ 35B**	

(1) Mean Time between Maintenance. F-22 ORD established MTBM threshold at 3 hours.
(1a) MTBM of 0.65 hours achieved in Follow-on Operational Test and Evaluation (FOT&E).
(1b) IOT&E MTBM score 0.45 hours. F-22 will achieve MTBM of 0.825 hours at maturity (100,000 FH), if its reliability growth rate is similar to the historical rates of existing fighter aircraft programs.
(1c) Air Force Program Office projects F-22 to achieve 1.5 hours MTBM at maturity.

(2) O&S cost for 148 Primary Aerospace vehicle Authorization (PAA), 336 flying hours per aircraft per year for 24 years. Initial spares requirement for 182 Total Active Inventory (TAI), computed at $120M recurring flyaway cost each.

(3) Baseline assumes the Air Force projected 1.5 hours MTBM at maturity. At the F-22 ORD MTBM threshold of 3 hours, the estimated life cycle cost would be $4B lower than the baseline in constant 2006 dollars.

F-22 life cycle cost could be $5B – $7B (constant 2006) more if projected program reliability is not realized.

Return of R&M Investment
(Present Value 2006 $B)

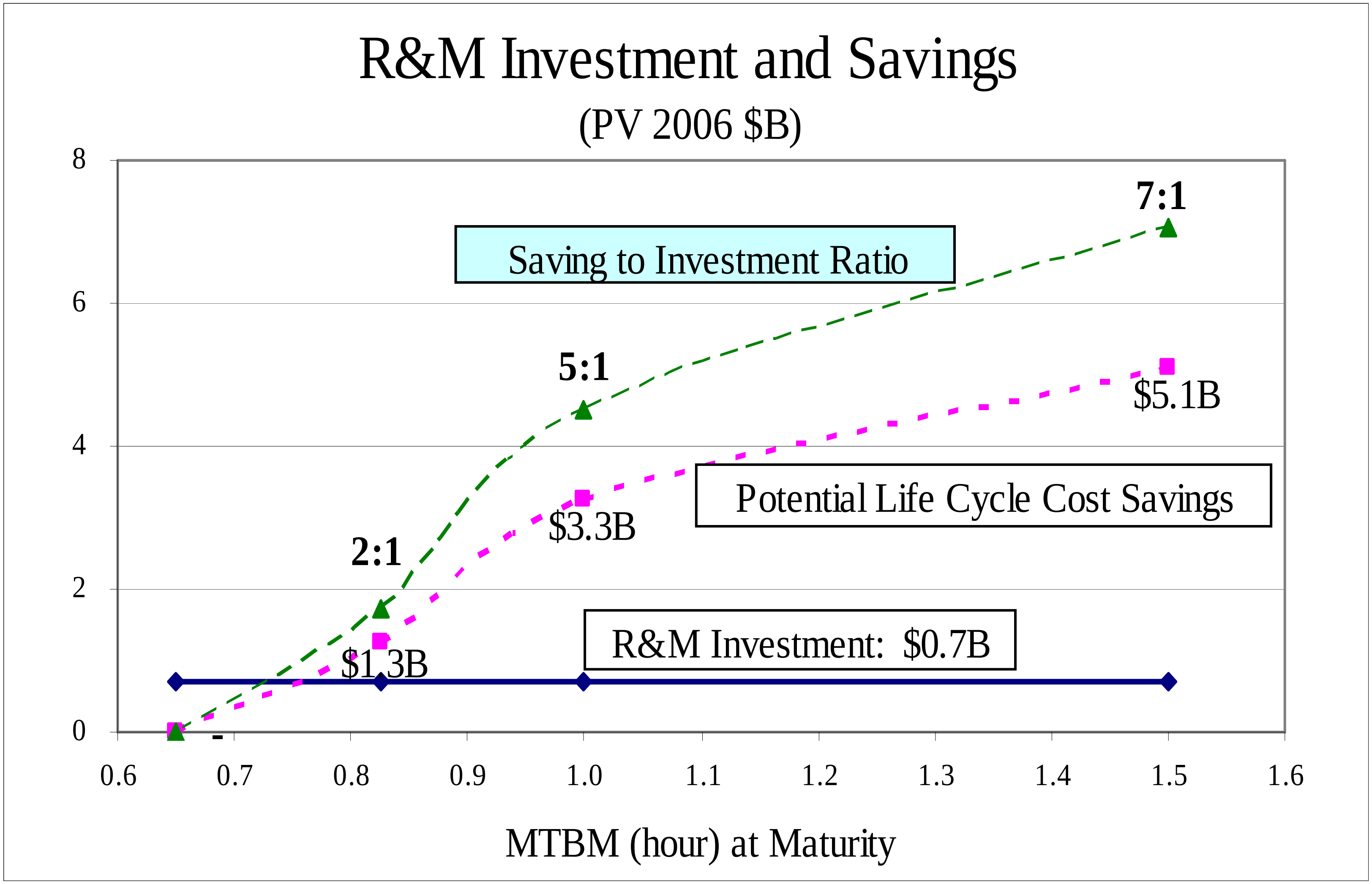
Reliability Level at Maturity	MTBM in Hours (1)	O&S & Initial Spares (2)	RDT&E & Retrofit (3)	Savings to Investment Ratio
FOT&E Actual	0.65	$ 30B		
Air Force Program Reliability Projection	1.50	$ 25B		
Potential Savings (4)		**$ 5B**		
Budgeted Investment			**$ 0.7B**	
Potential Return of Investment				**7 : 1**

(1) Mean Time between Maintenance. F-22 ORD established MTBM threshold at 3 hours.
F-22 Follow-on Operational Test and Evaluation (FOT&E) MTBM score 0.65 hours.
Air Force Program Office projects F-22 to achieve 1.5 hours MTBM at maturity.

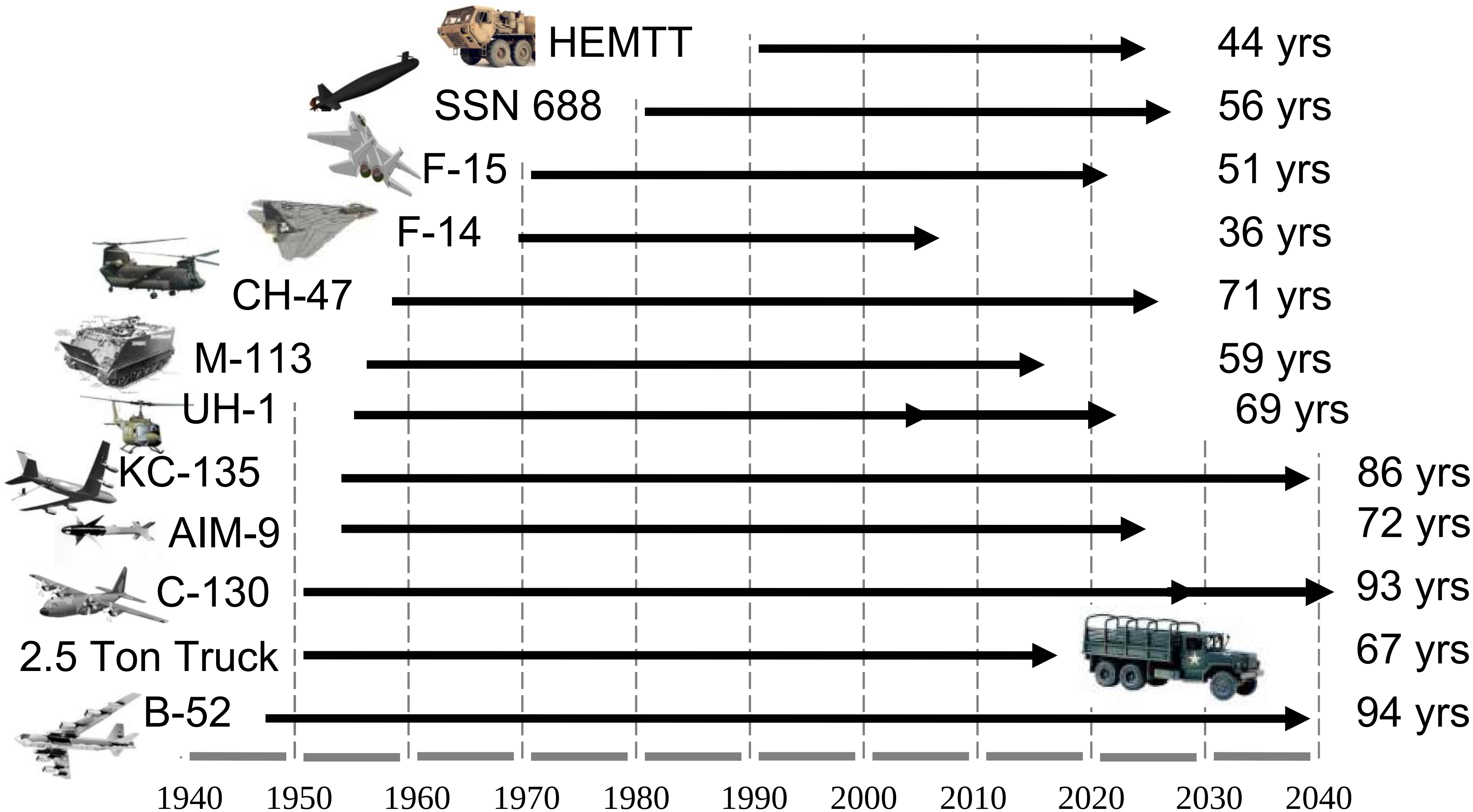
(2) O&S cost for 148 Primary Aerospace vehicle Authorization (PAA), 336 flying hours per aircraft per years for 24 years.
Initial spares requirement for 182 Total Active Inventory (TAI), costed at $120M recurring flyaway cost per aircraft.

(3) President Budget Submission (February 2005 and February 2006):
F-22 Reliability and Maintainability Maturation Program (RAMMP).
F119 engine Component Improvement Program (CIP).
R&M retrofits: air vehicle RAMMP modification and F119 engine CIP modification

(4) Saving will be substantially lower if F-22 does not achieve MTBM of 1.5 hours at maturity.


R&M Investment and Savings
(PV 2006 $B)
8
6
4
2
0
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
MTBM (hour) at Maturity
Saving to Investment Ratio
Potential Life Cycle Cost Savings
R&M Investment: $0.7B
7:1
5:1
2:1
$5.1B
$3.3B
$1.3B
-

Defense System Life Cycles



SOURCE: John F. Phillips DUSD (L)

Myths about Building-in Reliability, Availability and Maintainability

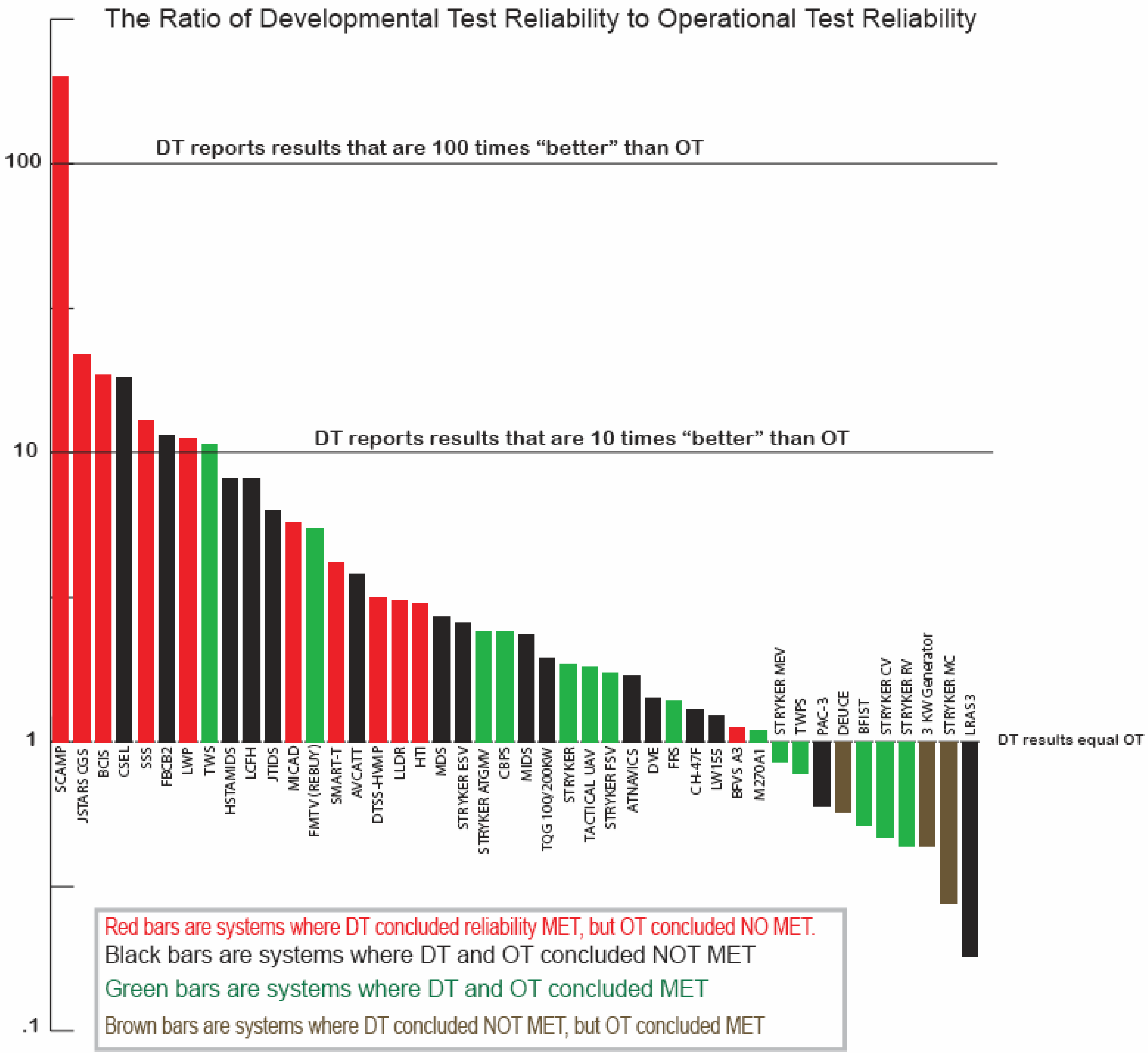
Myth 1: Building-in Reliability costs money.

HH-60H and MH-60S Reliability and Cost Comparison

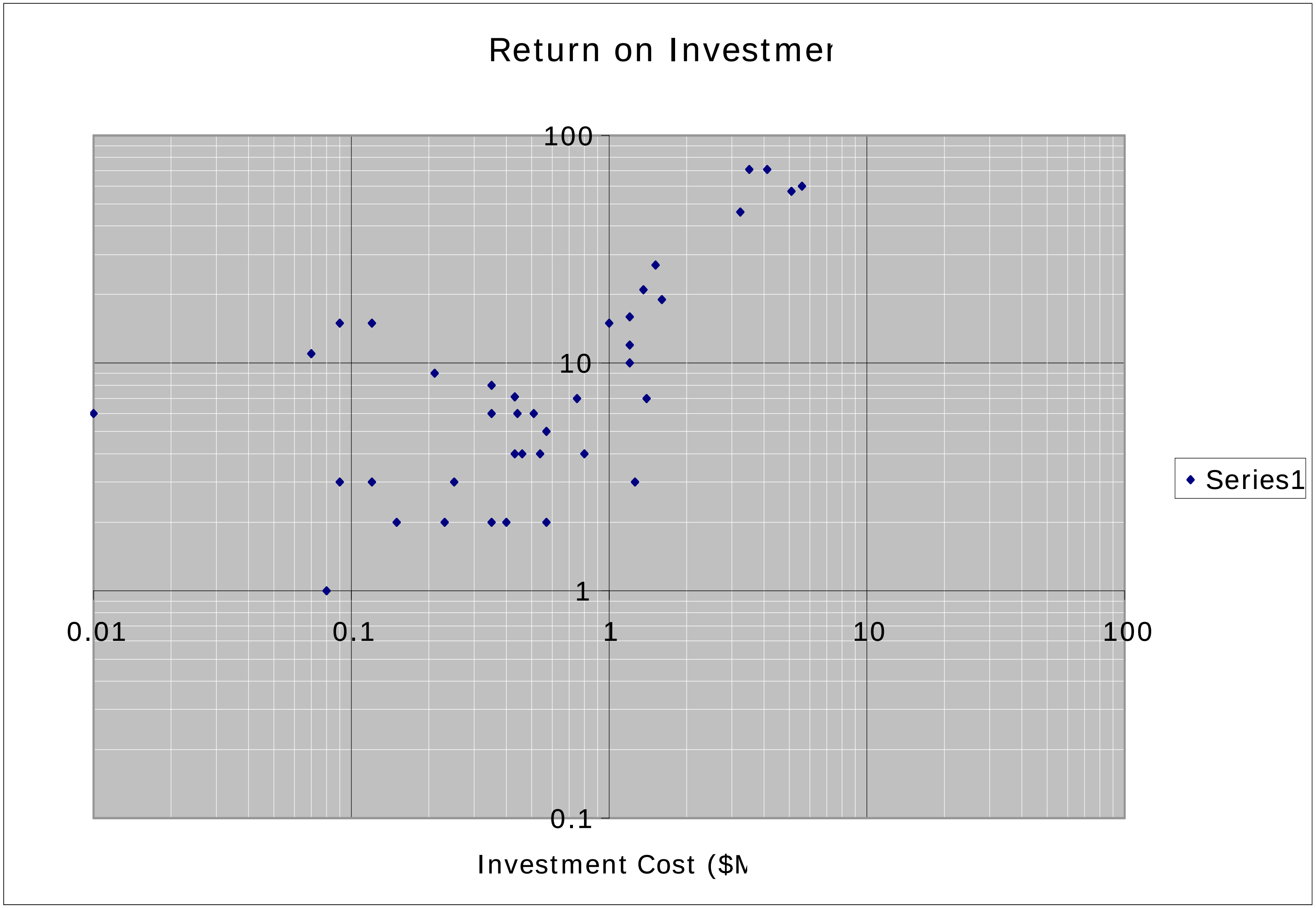
HH-60H			MH-60S		
Component	**MFHBR**	**PUC (FY07$K)**	**Component**	**MFHBR**	**PUC (FY07$K)**
CPU159/A AFCS COMPUTER	582	$180	CPU133/A DIGITAL COMPUTER	1,944	$86
AUXILIARY POWER SYSTEMS	2,160	$86	ACFT POWER UNIT	* >10,000	$80
SECT'S 2/3/4 DRIVE SHAFT ASSY	6,480	$4	SECTIONS 2/3/4 DRIVE SHAFT ASSY	* >10,000	$4
CP1820/ASN150 NAV COMPUTER	434	$99	CP-2428/A DIGITAL DATA COMPUTER	2,236	$84
STABILATOR AMPLIFIER INSTALL	549	$34	AMPLIFIER INSTALLATION	1,351	$43
MLG DRAG BEAM/AXLE ASSY	* >10,000	$24	BEAM-AXLE ASSEMBLY	* >10,000	$26
FLOOR ASSEMBLY	* >10,000	$10	AIRCRAFT FLOOR	* >10,000	$20
T1360( )/ALQ144(V) TRANSMITTER	582	$52	LIGHT,INFRARED TRANSMITTER	* >10,000	$5

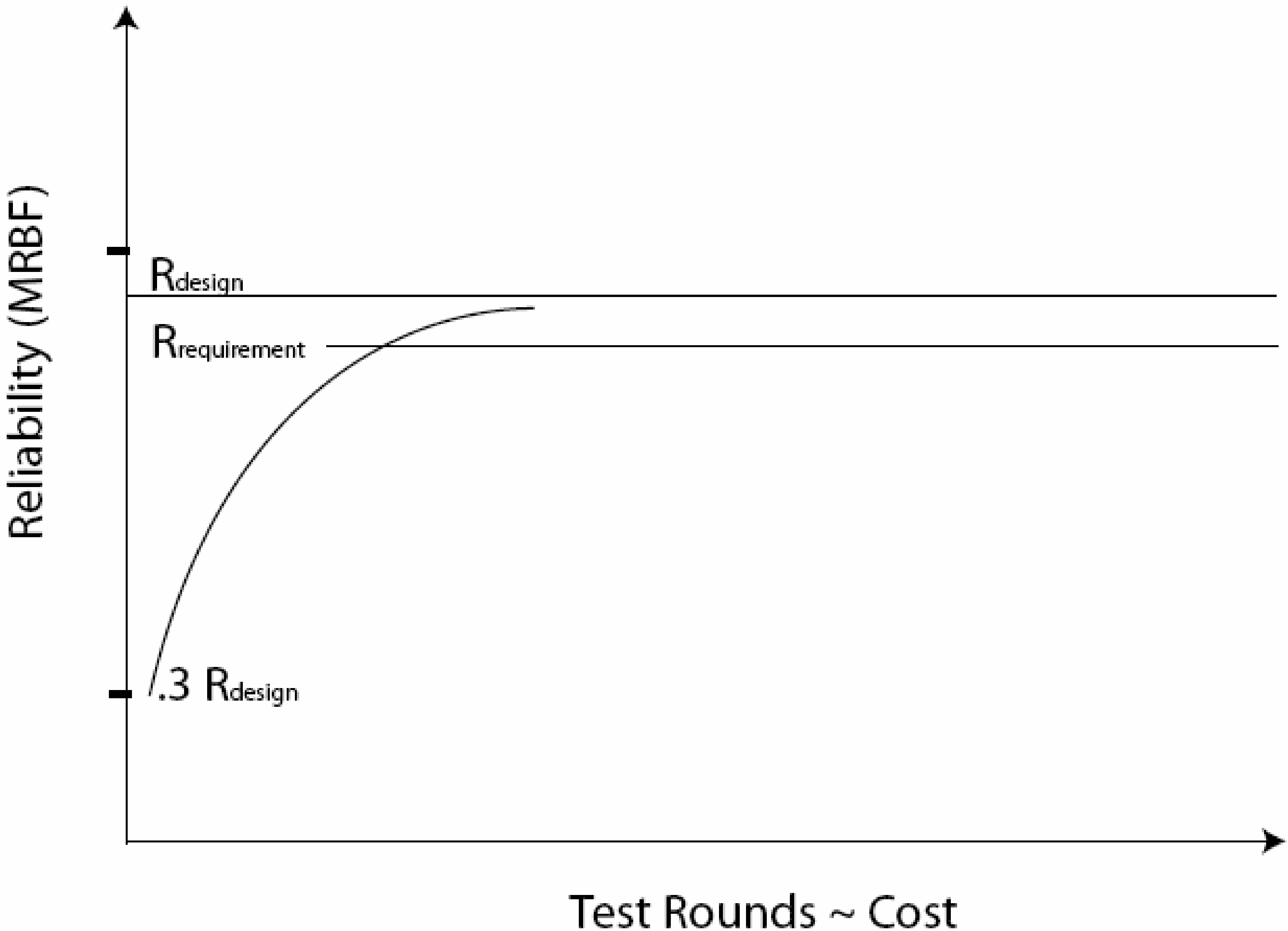
* 0 failures observed in one year

When to Invest?

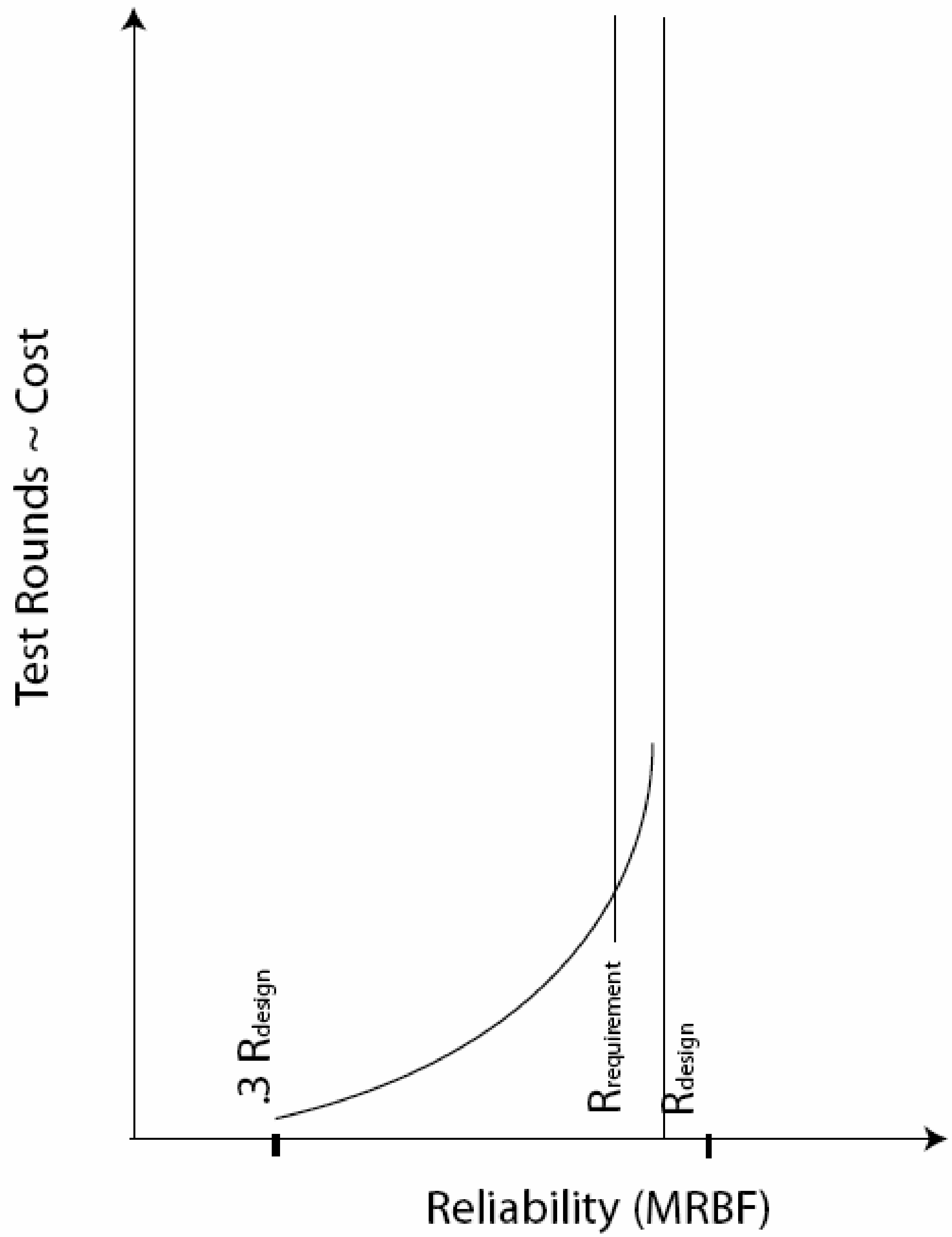


The Ratio of Developmental Test Reliability to Operational Test Reliability
100
10
1
.1
DT reports results that are 100 times "better" than OT
DT reports results that are 10 times "better" than OT
DT results equal OT
SCAMP
JSTARS CGS
BCIS
CSEL
SSS
FBCB2
LWP
TWS
HSTAMIDS
LCFH
JTIDS
MICAD
FMTV (REBUY)
SMART-T
AVCATT
DTSS-HWMP
LLDR
HTI
MDS
STRYKER ESV
STRYKER ATGMV
CBPS
MIDS
TQG 100/200KW
STRYKER
TACTICAL UAV
STRYKER FSV
ATNAVICS
DVE
FRS
CH-47F
LW155
BFVS A3
M270A1
STRYKER MEV
TWPS
PAC-3
DEUCE
BFIST
STRYKER CV
STRYKER RV
3 KW Generator
STRYKER MC
LRAS3
Red bars are systems where DT concluded reliability MET, but OT concluded NO MET.
Black bars are systems where DT and OT concluded NOT MET
Green bars are systems where DT and OT concluded MET
Brown bars are systems where DT concluded NOT MET, but OT concluded MET

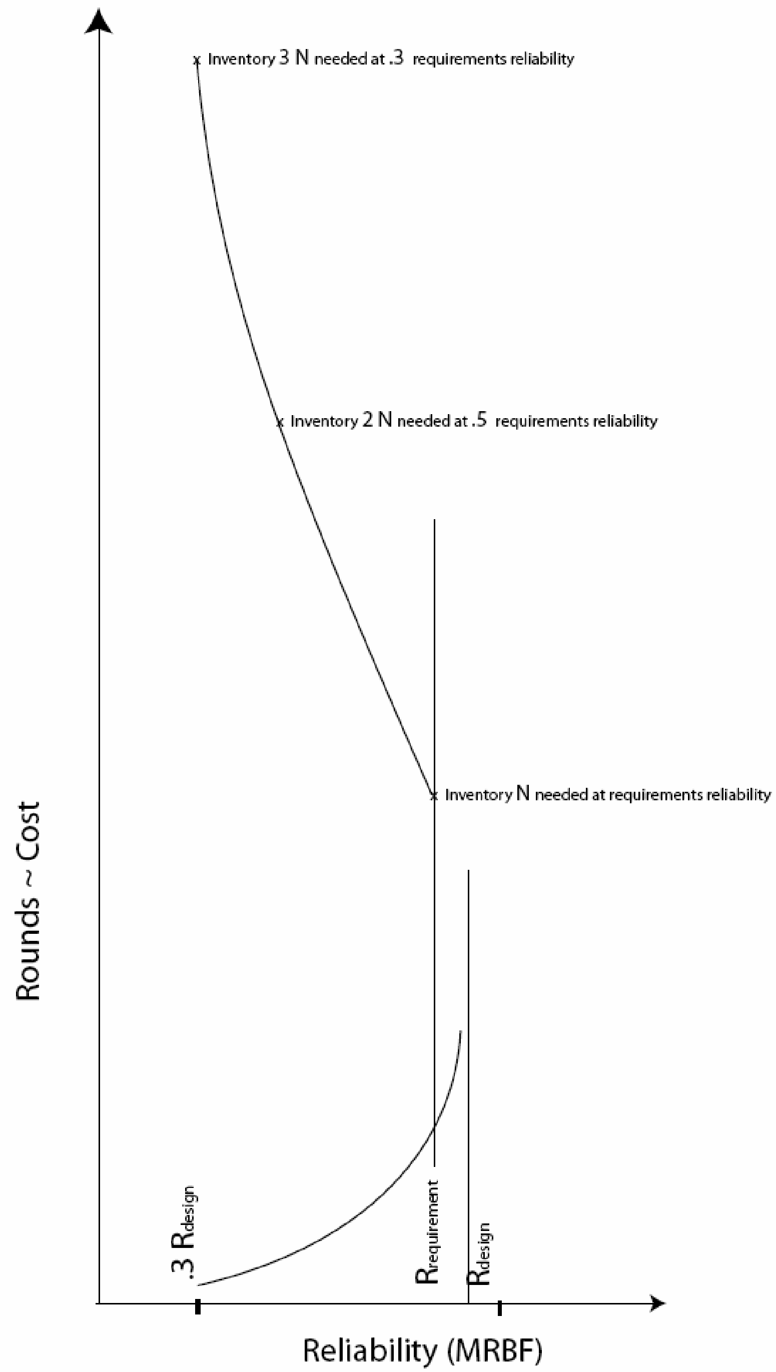

Return on Investmer
100
10
1
0.1
0.01
0.1
1
10
100
Series1
Investment Cost ($M



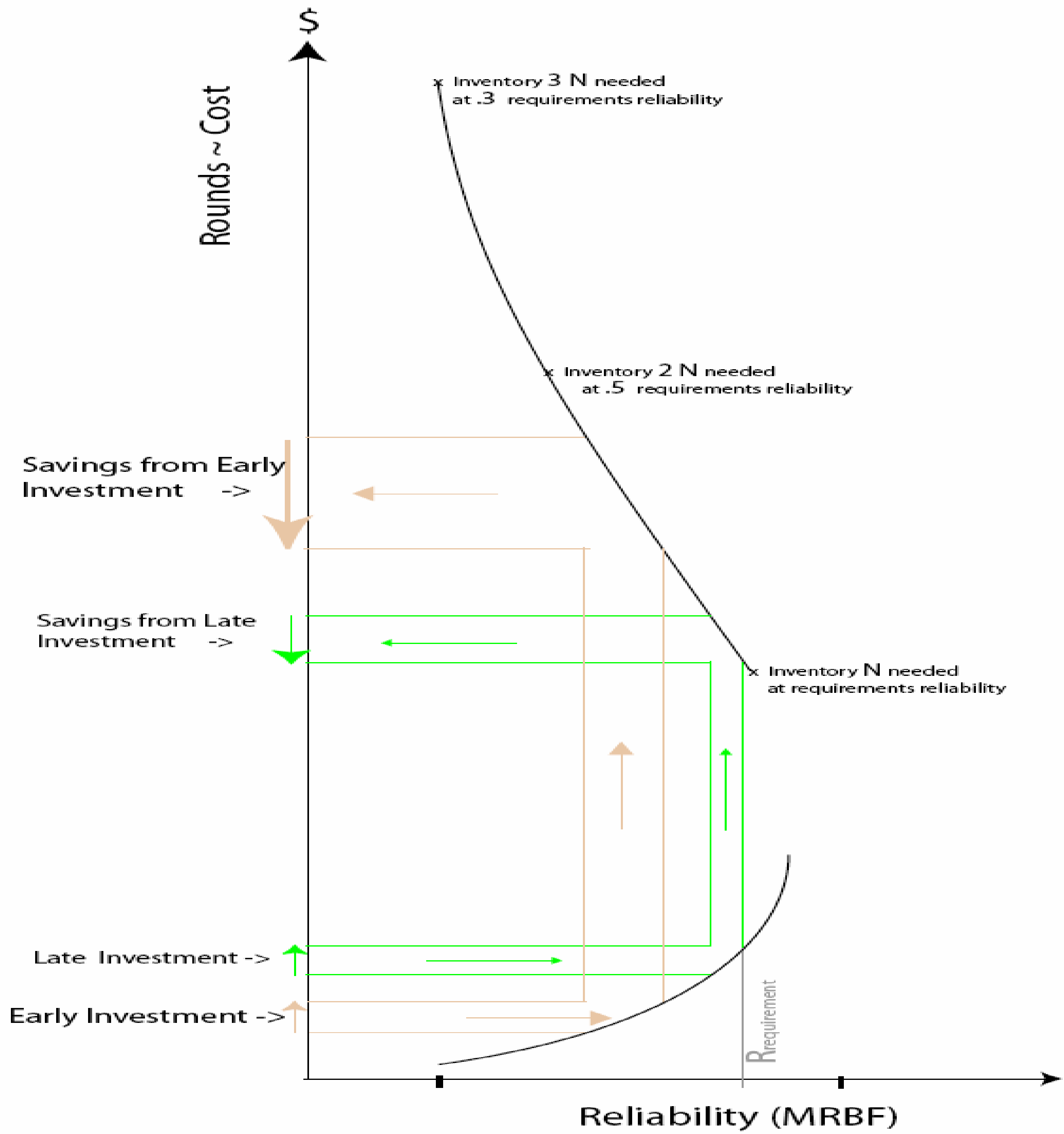
Reliability (MRBF)
R_{design}
$R_{requirement}$
$.3\ R_{design}$
Test Rounds ~ Cost



Test Rounds ~ Cost
.3 R_{design}
$R_{requirement}$
R_{design}
Reliability (MRBF)



Inventory 3 N needed at .3 requirements reliability
Inventory 2 N needed at .5 requirements reliability
Inventory N needed at requirements reliability
Rounds ~ Cost
.3 R design
R requirement
R design
Reliability (MRBF)

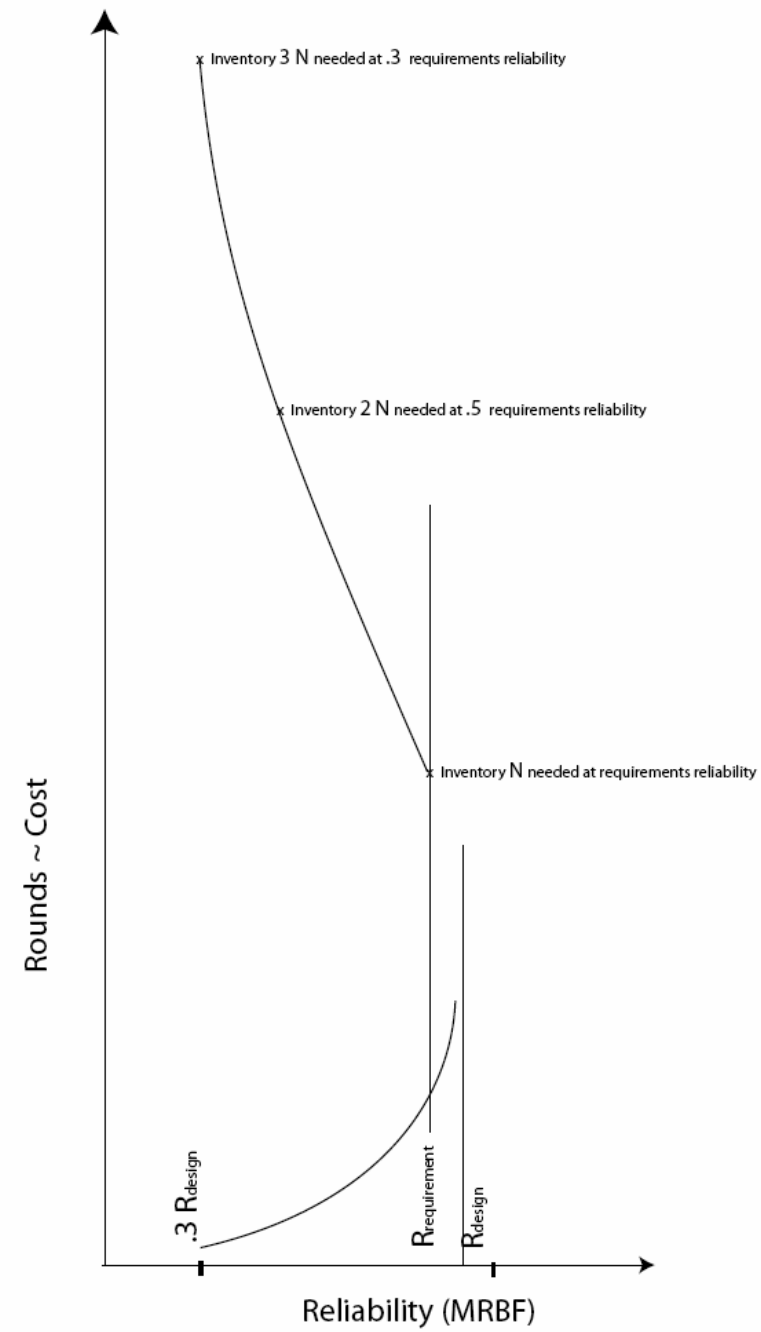


$
Rounds ~ Cost
x Inventory 3 N needed
at .3 requirements reliability
x Inventory 2 N needed
at .5 requirements reliability
Savings from Early
Investment ->
Savings from Late
Investment ->
x Inventory N needed
at requirements reliability
Late Investment ->
Early Investment ->
Rrequirement
Reliability (MRBF)

Summary

- How to Address Problems
- Size of ROIs?
- When to invest?

THE END



Inventory 3 N needed at .3 requirements reliability
Inventory 2 N needed at .5 requirements reliability
Inventory N needed at requirements reliability
Rounds ~ Cost
.3 Rdesign
Rrequirement
Rdesign
Reliability (MRBF)

SDD Investment for Operational Suitability

- Compare and contrast SDD/EMD approaches of cases with different emphasis on RAM (F/A-18 C/D vs. E/F; F-15 vs. F-16)
  - Design and Engineering
  - Schedule, costs, test articles
- Compare and contrast distinct DT approaches taken in cases and resulting suitability rating (JSOW, JASSM)
  - Standards and specifications
  - Schedule, cost, test articles
- Contractors' proposed fixes and associated costs for RAM issues

reduce total ownership costs (R-TOC)

grew out of (PEO/SYSCOM) Commanders' conferences, the Defense Science Board, and others. The R-TOC program was established in response to longstanding concerns about the adverse impact of defense budgetary and operational trends on force structure and readiness. Rising operations and support (O&S) costs can consume higher portions of defense budget and leave even less available for modernization.

The purpose of the R-TOC program is to achieve readiness improvements in weapon systems by improving the reliability of the systems or the efficiency of the processes used to support them. New Technologies and management practices may provide significant opportunities to improve readiness and reduce ownership costs. In recent years, world-class suppliers have achieved cost reductions while making major improvements in customer support. Some DoD programs have achieved similar successes in adopting private sector improvements in logistics and supply chain management.

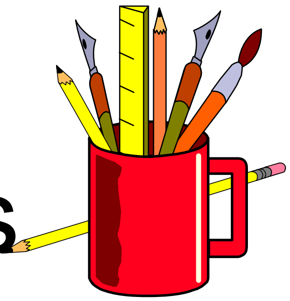
Weapon Systems
CH-47
Multiple
UH-60
AH-64
CH-47 & AH-64
H-47/H-64
Ground Support
Patriot Missle
B-1B
A-10
F-16
C-130
B-52
C-5A/F-15
F-15
F-15/Multiple
F-15 & F-16
KC-135
F100/F-119
Minuteman
Multiple (Fuel)

F/A-18
Multiple (Navy)
EA-6B
H-60
AV-8B
T-64
F404
AH-1/H-46
C-130/P-3
CH-46
E2-C-2
EA-6B, E-2/C-2
F/A-18 & E2/C2
H-1
HMMWV
T-58
T700
UH-1

Assessing Cost and R&M

- Models to link Mean Time Between Maintenance and other R&M metrics to requirements for
  - Maintenance manpower
  - Sustaining spares
  - Initial spares
- F-22 example
  - Compare the O&S cost and initial spares requirement for a range of reliability assumptions, following established analytical approaches for other F-22 Studies.
  - Tabulate the trade-off between budgeted F-22 R&M investment (RDT&E and retrofit) and potential O&S and initial spares savings.

RAM DESIGN:
Reliability Design Techniques



- Mission profile
- Stress analysis
- Worst case analysis
- FMECA
- Sneak circuit

- Allocation
- Parts selection
- Derating criteria
- Simplification
- Design reviews

Proposed Life Cycle Sustainment Outcome Metrics

- **Materiel Availability (KPP*)**
  - A Key Data Element Used In Maintenance And Logistics Planning
- **Materiel Reliability (KSA*)**
  - Provides A Measure Of How Often The System Fails/Requires Maintenance
  - Another Key Data Element In Forecasting Maintenance/Logistics Needs
- **Ownership Cost (KSA*)**
  - Focused On The Sustainment Aspects Of The System
  - An Essential Metric For Sustainment Planning And Execution
  - Useful For Trend Analyses – Supports Design Improvements/Modifications
- **Mean Downtime**
  - A Measure Of How Long A System Will Be Unavailable After A Failure
  - Another Key Piece Used In The Maintenance/Logistics Planning Process
- **Other Sustainment Outcome Metrics May Be Critical To Specific Systems, And Should Be Added As Appropriate**

* Sustainment KPP & KSAs Included In Revised Draft CJCSM 3170

These 4 Life Cycle Sustainment Outcome Metrics Are Universal Across All Programs And Are Essential To Effective Sustainment Planning

Stryker Findings & Observations

- **Warfighters very satisfied with Stryker performance in-theatre**
- **Brigade Commanders extremely happy with ICLS**
- **High Operational Readiness Rates, but ORR is prioritized over support costs**
- **Op Temp in-theatre far exceeds planned usage rates (X10, X15, X30 ?)**
- **Operational Environment much different than expected**
- **Combat configurations add excessive weight to vehicle (affecting reliability and performance)**
- **Army did not buy Tech Data Pkg – “Prohibitively expensive” . . . risk to government**

Findings & Observations

- **Operational Readiness Rate not necessarily consistent with traditional A_o**
  - RAM issues can be masked by ORR
- **Mission Completion vs. Subsystem Failure**
  - Possibly leads to overestimating system reliability due to non-reporting on individual subsystem (component) failures
  - Multi-mission vehicle – with subsystem failures, system can still perform alternate missions
- **Reporting Criteria Issue:**
  - ORR vs. MTBF of individual subsystems

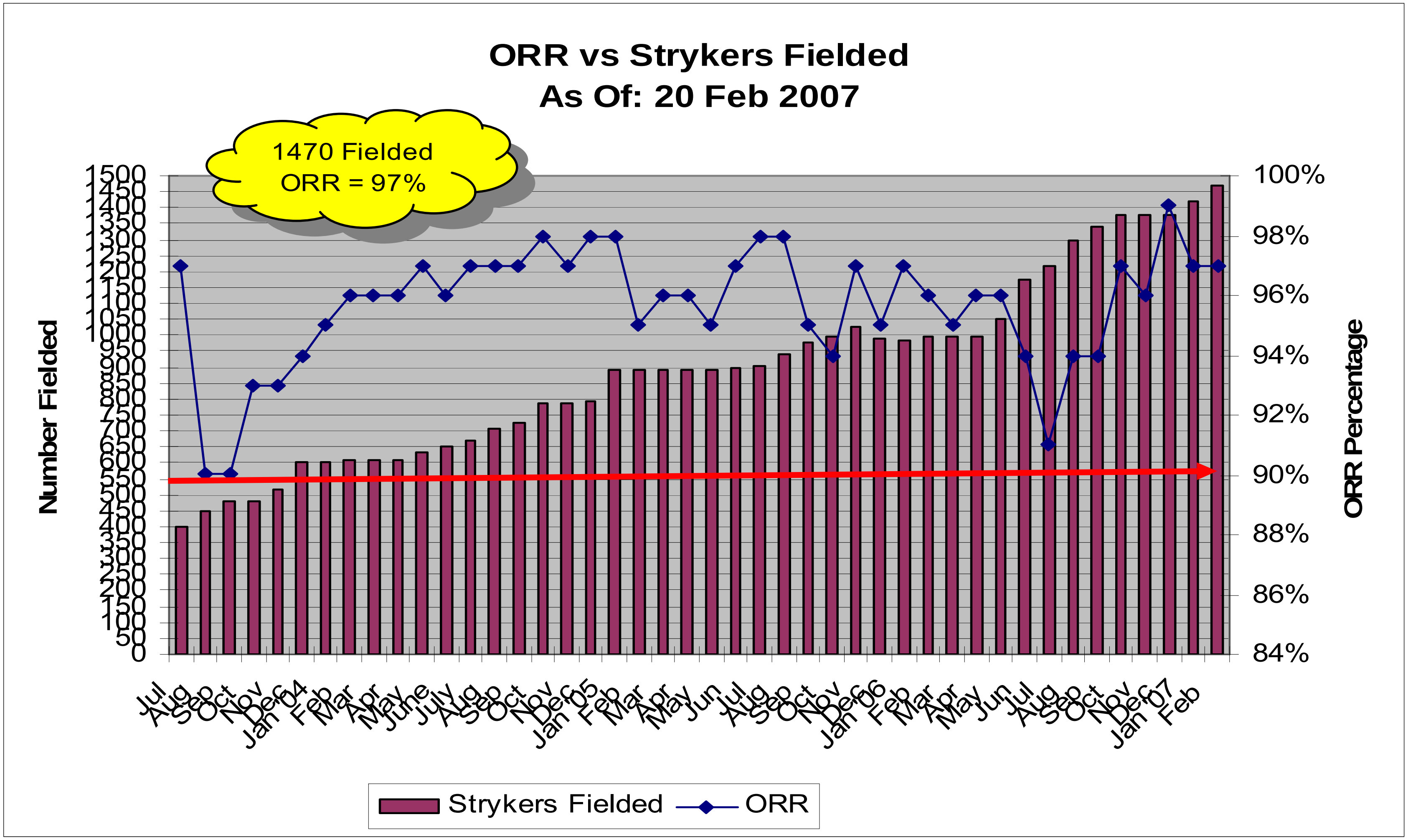
Reliability Issues

- RAM requirement poorly defined in ORD
  - 4.3.1.3. The Stryker (vehicle only, excluding GFE components/systems) will have a reliability of 1000 mean miles between critical failure (i.e., system aborts).
- Reliability issues and cost drivers found during DT/OT correlate well with in-theatre experience

Operational Environment

- **Field usage much harsher than planned**
  - e.g., higher tire pressure, roads, curbs, weight (armor, sandbags)
- **OMS/MP says 80% XCountry, 20% Primary Roads**
  - in-theater mission just the opposite . . . most missions in urban environment (police action) on paved roads
- **OpTempo very high (>10X)**
  - High OpTempo may improve reliability numbers, but beats up equipment
  - With low usage, seals can dry up, humidity can build up in electrical components
- **Changes in mission & configuration are putting excess stress on vehicle: armor/sandbags, over inflated tires, going over curbs**
  - replacing 9 tires/day (>3200 tires/yr)
  - wheel spindles developing fatigue cracks
  - drive shafts breaking
  - prescribed tire pressure is 80 PSI, however, with slat armor/sandbags – must maintain >95 PSI
  - 95 PSI is a logistics burden on operators
    - Must be maintained by the soldier (CTIS system can’t do it)
    - Soldiers must check tire pressure more than 3 times per day to maintain 95 PSI

Stryker Fleet Readiness



Operational Readiness Rate (ORR)

- **PBL Contractual Requirement: ORR $\geq$ 90%**
  - **Does not include GFE (base vehicle configuration only)**
- **Consistently above requirement**
  - **Current ORR 97% (20 Feb 07)**
- **Cost-plus-fixed-fee contract motivates GDLS to meet ORR . . . .**
  - **However, contract does <u>not</u> incentivise controlling costs . . . risk to government**
  - **Example – to repair cracked hyd res in power pack, whole power pack is replaced in field**

Cost Estimate Variation

- **CPM estimate - $17.19 (GAO 04-925, including labor, parts & repair)**
- **CPM estimate - $18.78 (Stryker R-TOC Brief)**
- **CPM estimate - $18.23 (based on M113 methodology w/Stryker adjustments)**
- **CPM estimate - $14.53 (based on initial 4 month deployment data)**
- **CPM estimate - $12.72 (GDLS estimate, labor, parts & repair)**

- **We need to understand the basis for these estimates more thoroughly (assumptions, models, configurations, limitations . . .)**

Tactical Considerations

- **Slat Armor design (additional 5000 lb) is effective for many RPG threats, but negatively impacts circumference, weight and performance of Stryker**
  - **Causes multiple problems for safe and effective operation**
    - **Slat armor on rear ramp too heavy - greatly strains lifting equipment**
      - **Occasionally, crews must assist raising/lowering ramp**
    - **Bolts on rear ramp break off frequently with normal use**
    - **Slat armor bends with continued ops . . . can cover escape hatches and block rear troop door in ramp**
    - **Interferes with driver's vision**
    - **Slat armor difficult to see at night . . . Safety hazard in urban environment**
    - **Slat Armor prohibits normal use of exterior storage racks**
  - **Significantly impacts handling/performance in wet conditions**
    - **Excessive strain on engine, drive shafts, differentials**
  - **Impairs off-road ops**
- **Though not designed primarily for the urban fight (MOUT), Stryker is well-suited for it**
  - **Unlike M-1, Stryker is "Ghostly" quiet . . . tactical advantage**
- **Stryker overall OIF performance significantly better than HUMVEE, BRADLEY or M-1 in this environment**

Other Findings . . . cont.

- **Stryker initial deployment/fielding was extremely accelerated to meet urgent combat need**
  - **Result was that Army was doing these things concurrently:**
    - **Testing**
    - **Producing**
    - **Fielding**
    - **Conducting combat operations**
- **Immature Maintenance Procedures (many procedures have not been validated in IETMs) lead to:**
  - **"*Tribal System Maintenance*" from experienced crews (that new book isn't any good . . . . this is the way it worked on the M113, so do it like this)**
- **With Kr support to maintain vehicles, soldier crews develop "*rental car mentality*" . . .**
  - **Overly dependent on Kr . . . . lack of ownership mentality**
  - **Sometimes they forget the basics (oil check)**
  - **One vehicle lost because pre-mission checks were ignored**
    - **maybe lack feeling of ownership, maybe overly depend on Kr**

Typical Suitability Requirements

- Logistic Support
  - Deployability of Forces and Equipment
- Training
  - Ability to Train Maintenance Personnel
- Ability to Launch Aircraft
  - Sortie Generation Rates (Peacetime and Wartime)
- Reliability and Maintainability (R&M)
  - Break Rate, Fix Rate
  - Mean Time Between Maintenance (MTBM)
  - Mean Time Between Removals (MTBR), Mean Down Time
  - Mission Capable Rate and Weapon System Reliabilities

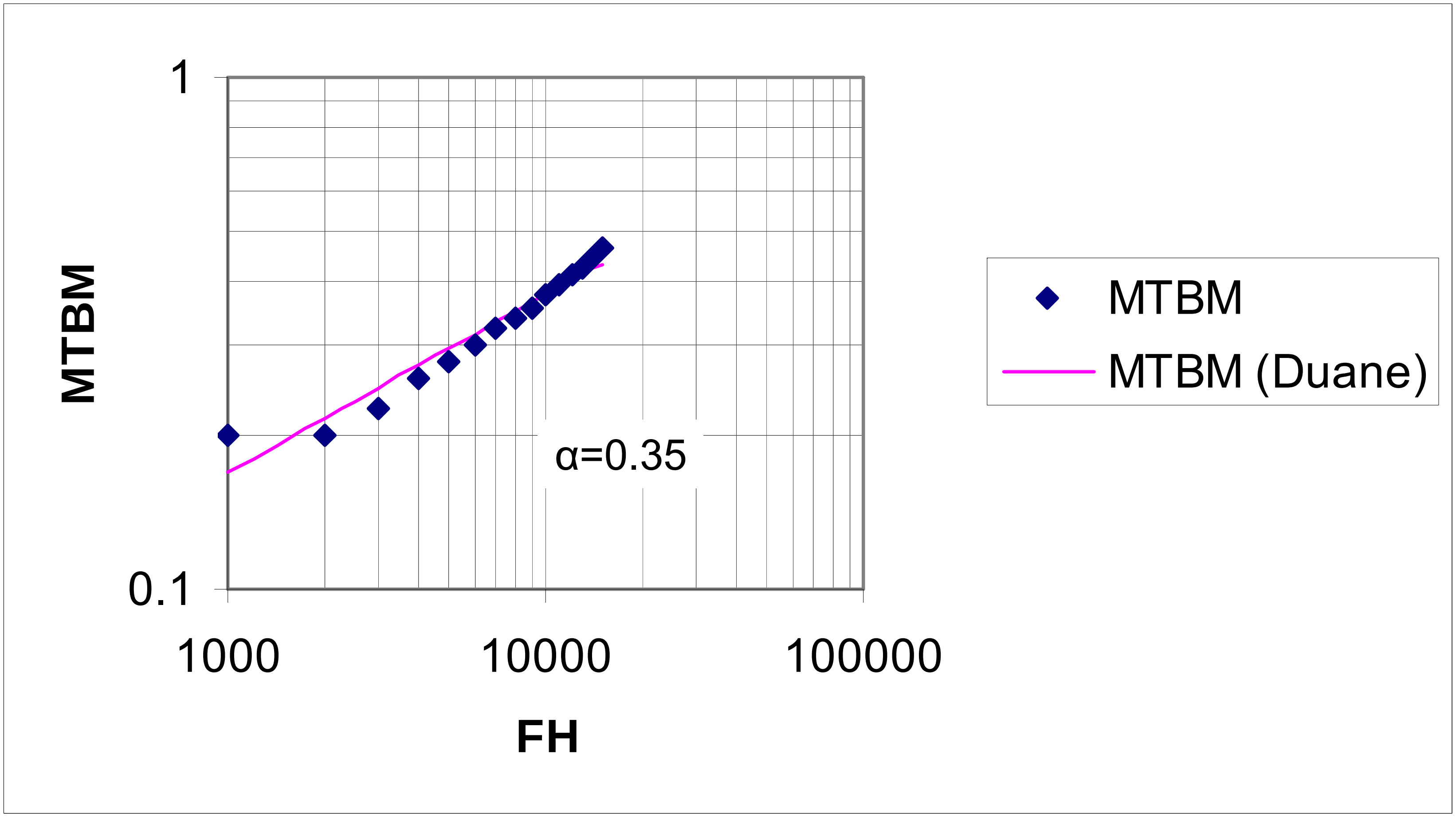
Unsuitability issues are often R&M related

- high Break Rate, low Fix Rate, low MTBM, low MTBR

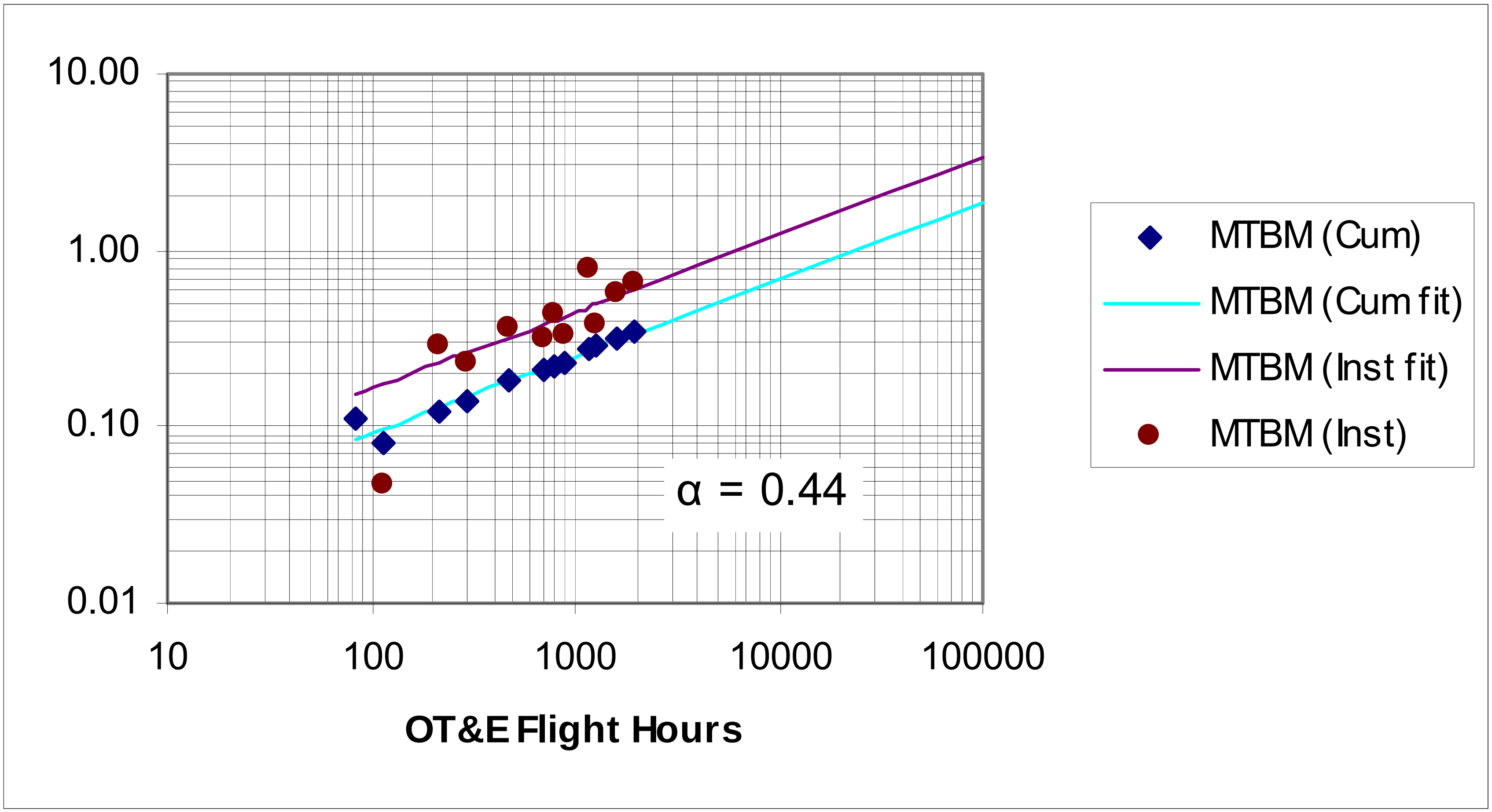
Elements Affected by R&M

- Poor R&M leads to more frequent maintenance/repair and longer time to repair/replace.
  - More initial spares = > higher procurement cost
  - More repair parts = > higher operating and support (O&S) cost
  - More maintenance manpower
    = > higher O&S cost
- To correct the shortcoming in R&M after full rate production requires:
  - Operational System Development to design and test fixes
    = > additional RDT&E cost
  - Retrofit existing production units
    = > additional modernization cost
- Poor R&M lowers sortie generation rate, could necessitate additional procurement

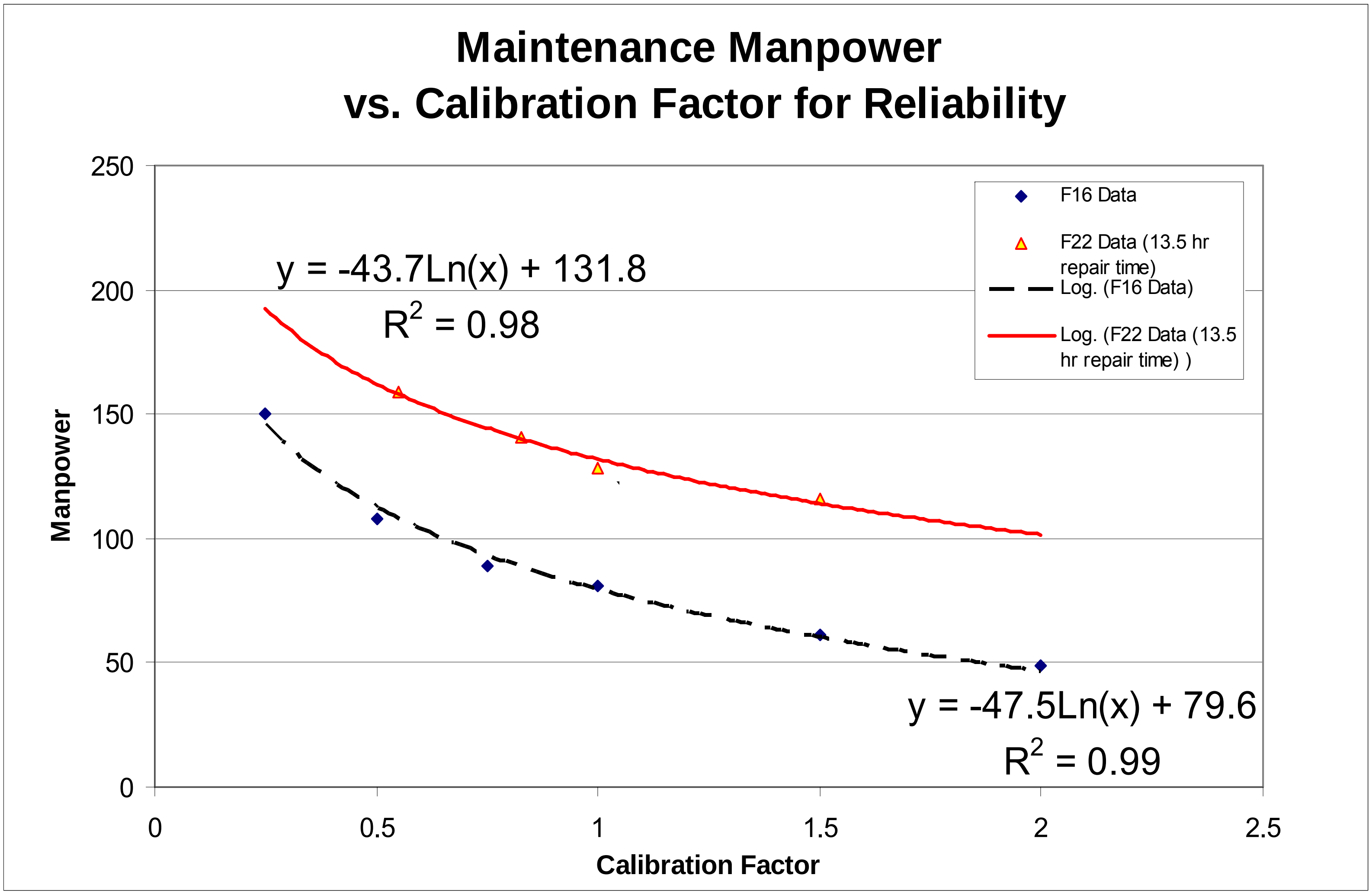
C-17 MTBM (Cumulative)



F-22A Mean Time Between Maintenance (MTBM)



IMEASURE



Maintenance Manpower
vs. Calibration Factor for Reliability
F16 Data
F22 Data (13.5 hr repair time)
Log. (F16 Data)
Log. (F22 Data (13.5 hr repair time))
y = -43.7Ln(x) + 131.8
R2 = 0.98
y = -47.5Ln(x) + 79.6
R2 = 0.99
Manpower
Calibration Factor
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5

Estimate O&S and Initial Spares of Different F-22 MTBMs

(Present Value 2006 $B)

Reliability Level at Maturity		MTBM in Hours (1)	O&S & Initial Spares (2)	Life Cycle Cost Difference (3)
FOT&E Actual	(1a)	**0.65**	**$ 30B**	**$ 5B**
IOT&E Actual with Historical Growth	(1b)	**0.83**	**$ 29B**	**$ 4B**
Air Force Program Reliability Projection	(1c)	**1.50**	**$ 25B**	

(1) Mean Time between Maintenance. F-22 ORD established MTBM threshold at 3 hours.

(1a) MTBM of 0.65 hours achieved in Follow-on Operational Test and Evaluation (FOT&E).

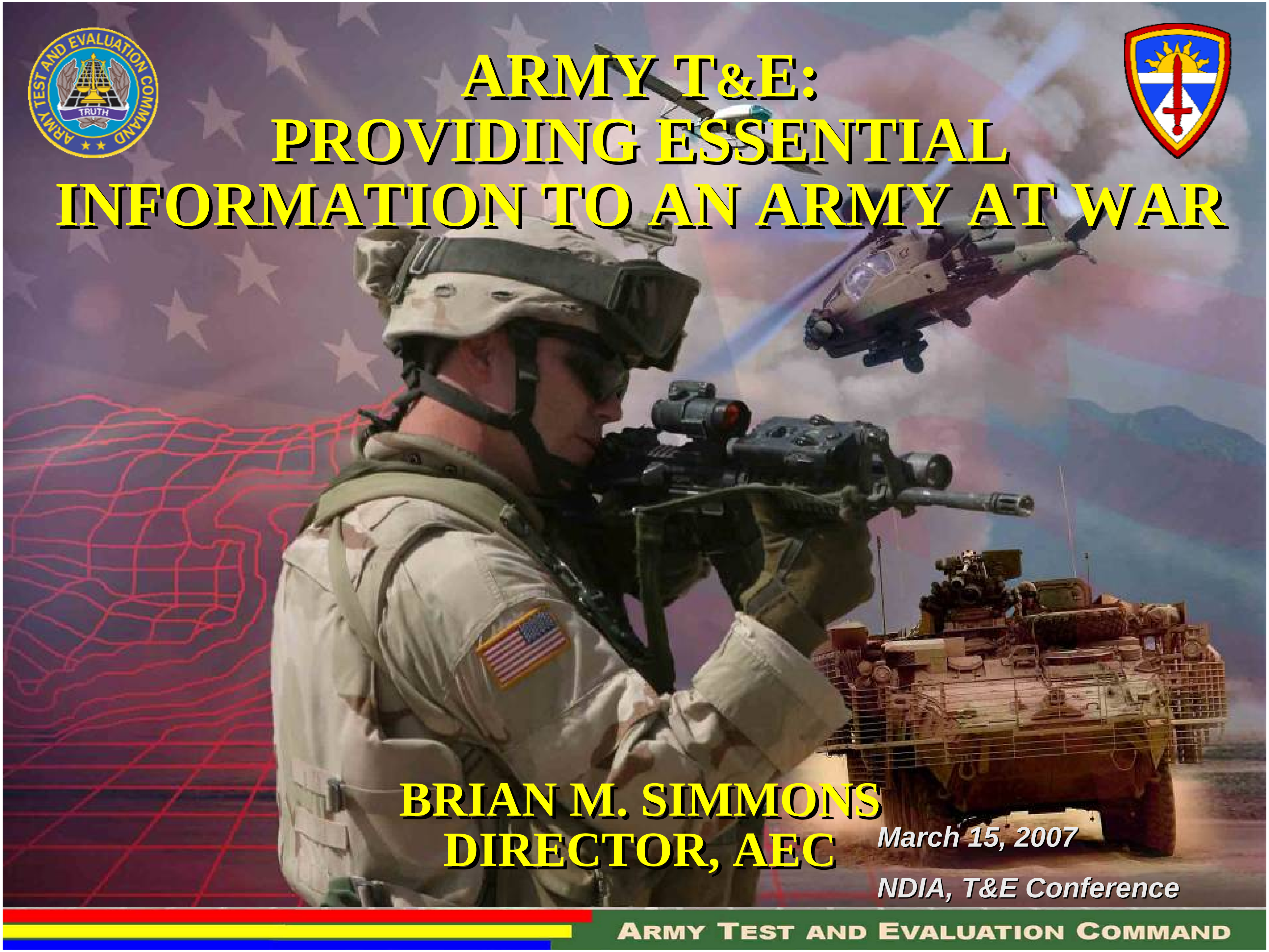
(1b) IOT&E MTBM score 0.45 hours. F-22 will achieve MTBM of 0.825 hours at maturity (100,000 FH), if its reliability growth rate is similar to the historical rates of existing fighter aircraft programs.

(1c) Air Force Program Office projects F-22 to achieve 1.5 hours MTBM at maturity.

(2) O&S cost for 148 Primary Aerospace vehicle Authorization (PAA), 336 flying hours per aircraft per year for 24 years. Initial spares requirement for 182 Total Active Inventory (TAI), computed at $120M recurring flyawy cost each.

(3) Baseline assumes the Air Force projected 1.5 hours MTBM at maturity. At the F-22 ORD MTBM threshold of 3 hours, the estimated life cycle cost would be $3B lower than the baseline in 2006 present value.

F-22 life cycle cost could be $4B – $5B more in 2006 present value if projected program reliability is not realized.


ARMY T&E:
PROVIDING ESSENTIAL
INFORMATION TO AN ARMY AT WAR
BRIAN M. SIMMONS
DIRECTOR, AEC
March 15, 2007
NDIA, T&E Conference
TRUTH
ARMY TEST AND EVALUATION COMMAND
ARMY TEST AND EVALUATION COMMAND

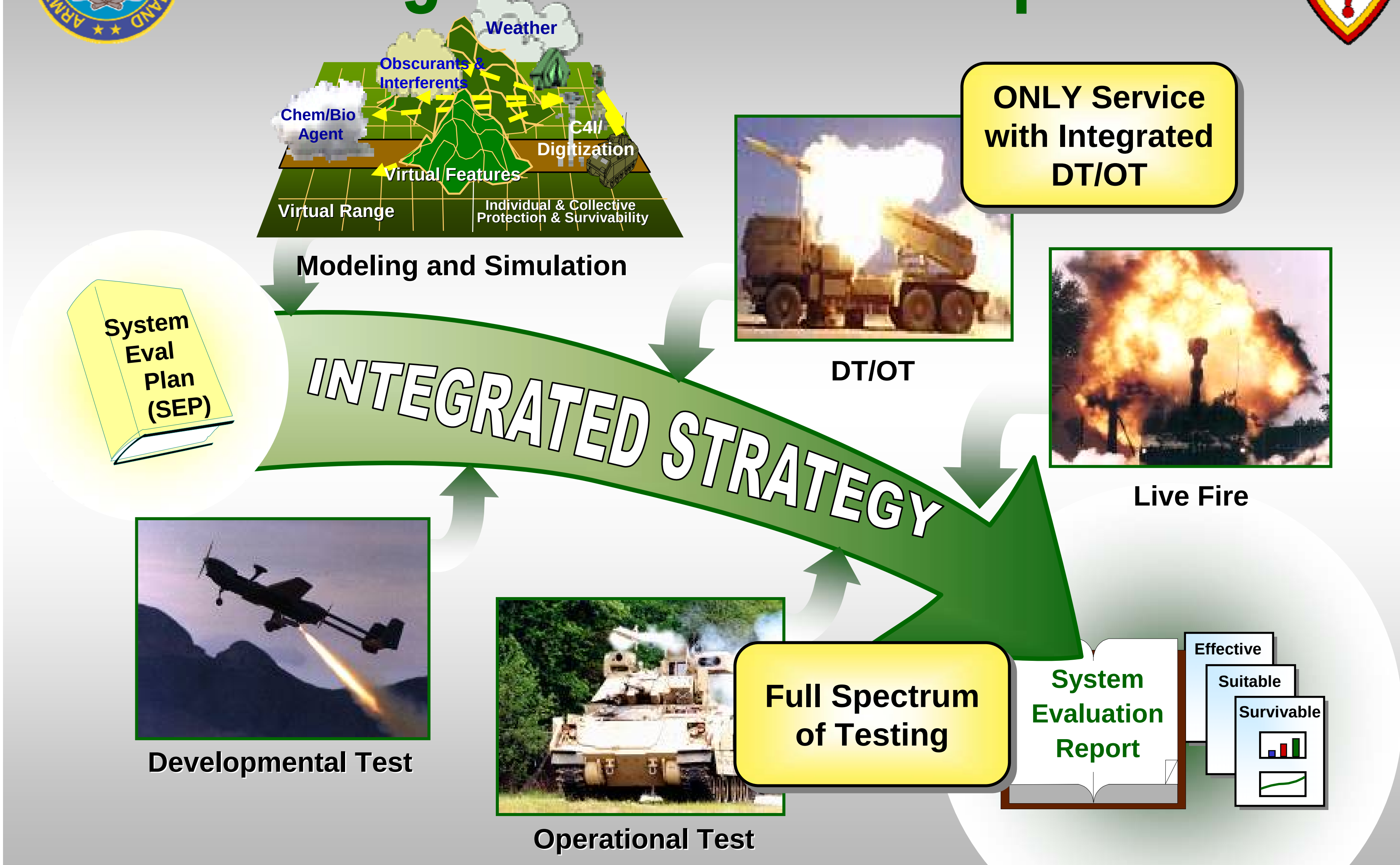
ATEC Mission

- Plan, conduct, and report the results of tests, simulations, experiments, and evaluations to Acquisition decision makers in order to ensure our Army's Warfighters have the right capabilities for success across the entire spectrum of operations.
- Conduct rapid testing in direct support of the GWOT warfighter in order to provide capabilities and limitations of untested weapon systems issued directly to Soldiers conducting combat operations (Iraq/Afghanistan).

Tenets of Testing

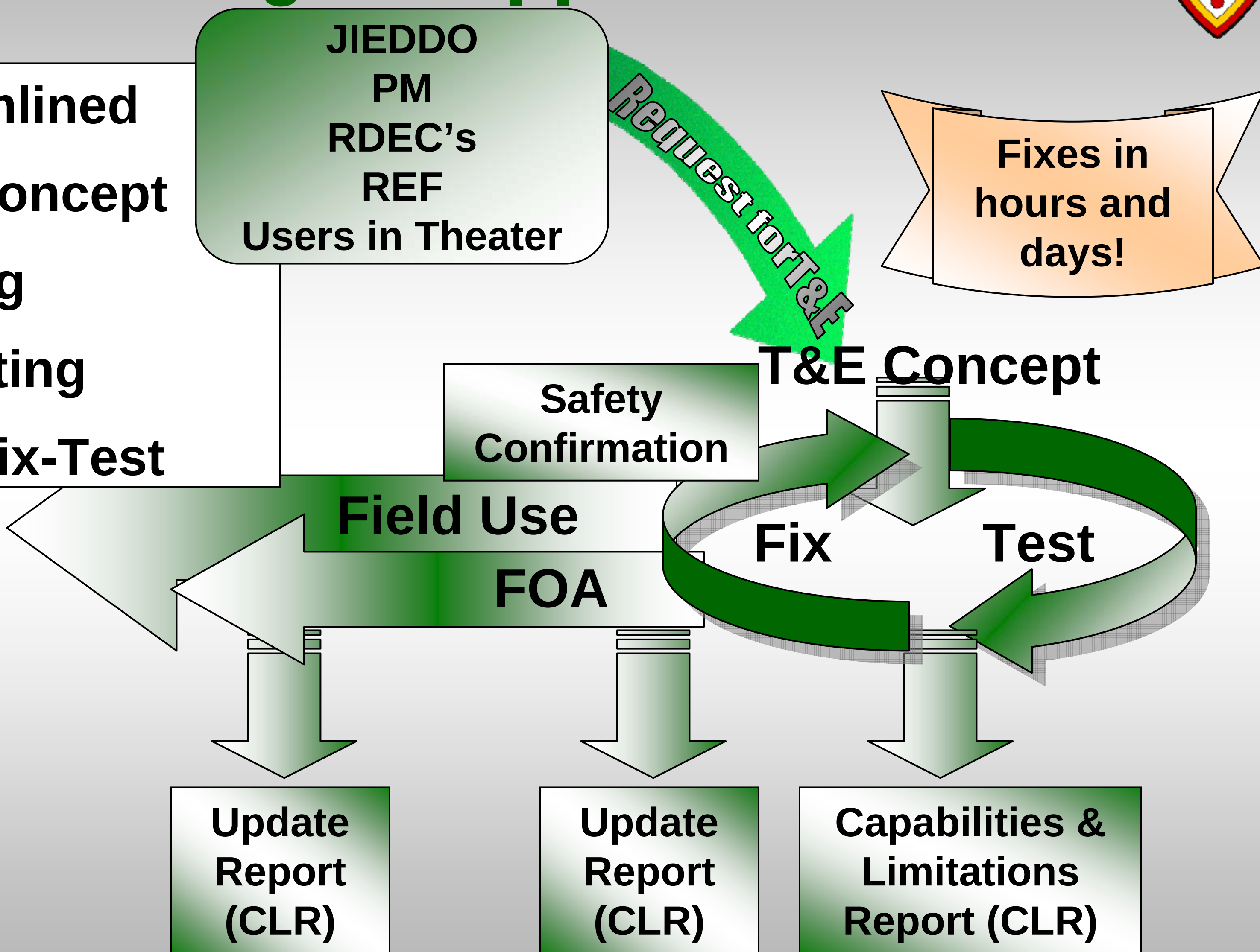
- **Standards are the same**
  - **GWOT**
  - **Normal Acquisition**
- **Test Strategy tailored to meet Acquisition Strategy**
- **Must answer 2 Questions**
  - **"Does it work…How do I know?"**

Testing for Traditional Acquisition



Testing in Support of GWOT

- Streamlined
- T&E Concept
- Testing
- Reporting
- Test-Fix-Test



Tailored Testing Examples

GWOT DT/OT
Less Than
90 Days

DT/OT - 44 Days

C&L Report - 12 Days

GWOT C&L
Less Than
14 Days

Armor Coupon Shots – 48-hr Response to Theater

DT/OT - 58 Days

C&L Report - 6 Days

"Does It Work...How Do I Know?"

Tailored Testing

Managing Risk

- Tailor each weapon system T&E concept
- Full Spectrum vs. OIF/OEF
- Environmental
- Durability: Combat Opns today vs. Full Life Cycle Reliability

TEST SCOPE

Rapid Acquisition Testing Gaps

- Interoperability
- TTP/CONOPS
- Training (Leader, Individual, Collective, Sustainment)
- Logistics Concept
- Not all systems fit the Rapid Testing "Model"

ATEC Forward

MISSION:

- **Provide Essential Info to Sr. Army Leadership**
- **Test & Collect data on selected Warfighting systems**
- **Multi-Unit Liaison with MNC-I, CFLCC, CJTF-76, and CENTCOM HQs**
- **Obtain direct feedback from Soldiers**

C2 Node

Team Afghanistan

Log Support

Summary

- ATEC Fully Engaged in GWOT
- Not all systems fit the Rapid Testing “Model”
- Right Size the Test
- Mitigate the Risk
- Follow the System thru GWOT & Beyond
- “Does It Work…How Do I Know?”

Measurement and Detection Standards from The Theory of Inventive Problem Solving

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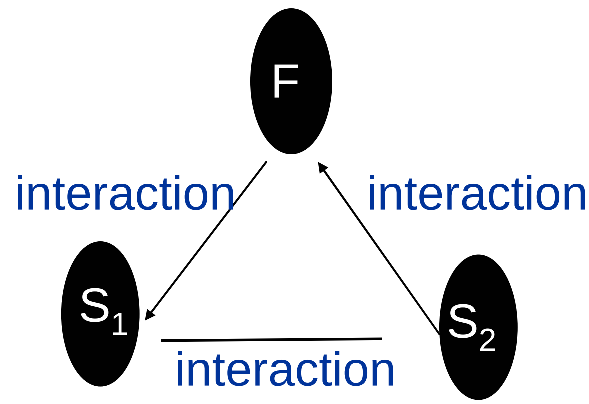
TRIZ: The Theory of Inventive Problem Solving

- **Systematic Problem Solving Methodology**
  - **Empirically Derived Techniques**
    - Ideality
    - Technical Contradiction Theory
    - Levels of Innovation
    - Maturity Mapping
    - Technology Forecasting
  - **Heuristics**
    - Psychological Bias
    - Ideal Final Result
    - Physical Contradiction Theory
    - System Approach
    - ARIZ
    - **Substance-Field Modeling**
      - **76 Standard Solutions and algorithm**

Simplify, Perfect, Innovate

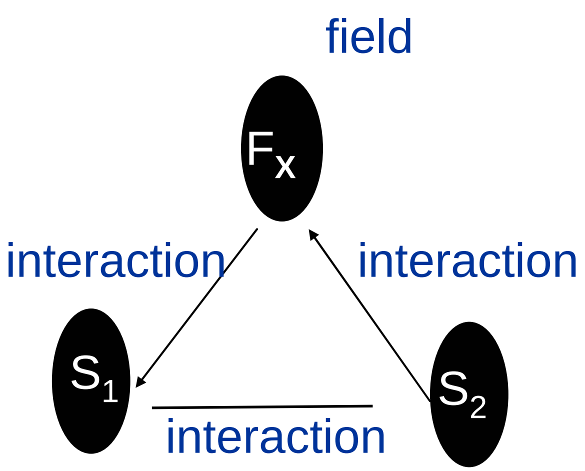
SFM: Substance-Field Modeling

- **Modeling Technique**
  - **Describes the Interactions within a System Triad:**
    - **Field, F**
    - **Substance 1, S_1**
    - **Substance 2 , S_2**



The Fields, F_X

- **Mechanical, F_{Me}**
- **Electrical, F_E**
- **Thermal, F_{Th}**
- **Chemical, F_{Ch}**
- **Magnetic, F_M**
- **Electromagnetic, F_{EM}**
- **Nuclear, F_N**
- **Compound Fields:**
  - **E-Me**
  - **Th-Ch**
  - **E-Ch, etc.**



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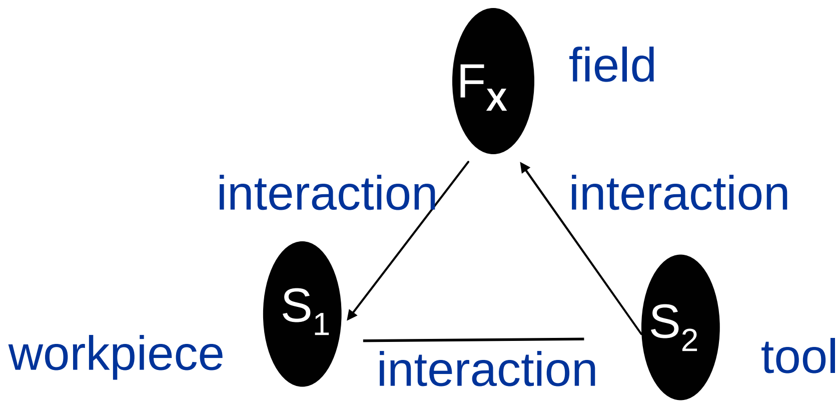
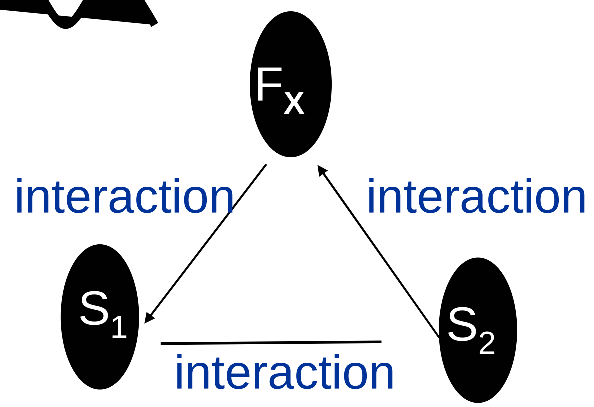
The Substances: S_1 and S_2

- S_1 is known as the ***workpiece***
- S_2 is the ***tool***
- The ***tool*** is applied to the ***workpiece*** and the interaction is described by a ***field*** and the resultant ***interactions***
- Energy flows from the ***tool*** to the ***workpiece***



The Interactions

- Sufficient:
- Insufficient:
- Harmful:



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Modeling Examples

- S1: wall
- S2: person
- F: painting

- S1: wall
- S2: paint
- F: adhesion

- S1: wall
- S2: brush
- F: application

- S1: paint
- S2: brush
- F: application

- S1: brush
- S2: person
- F: moving application

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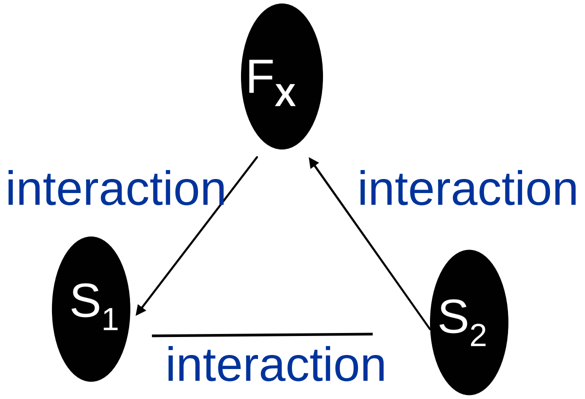
Simplify, Perfect, Innovate

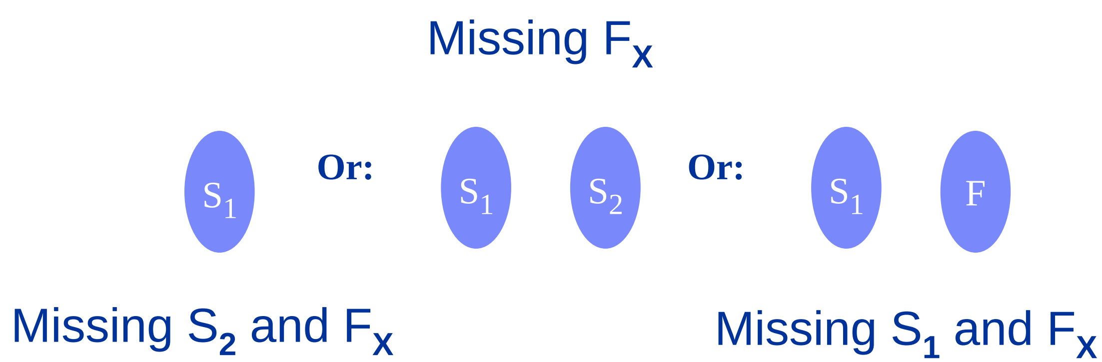
Incomplete, Insufficient, or Systems with Harm

- The minimum functioning system model involves a complete triad: F_X, S_1, S_2, and each interaction (3 minimum)
  - A system that is missing any of those elements is <u>incomplete</u>
  - An <u>incomplete</u> should be completed



The Incomplete Model

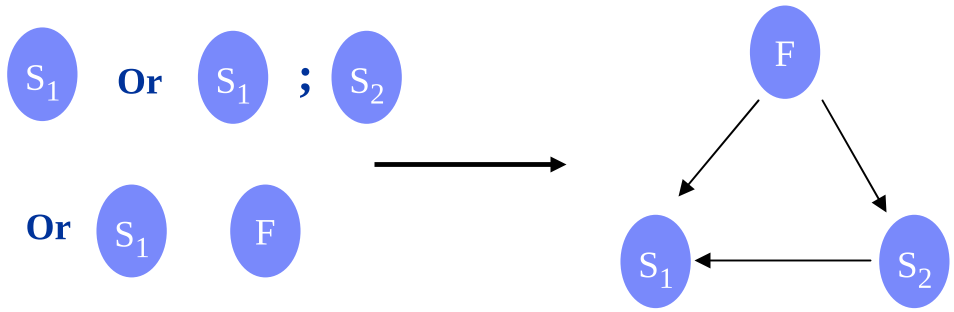
One or two elements of the minimum technical system are missing



Simplify, Perfect, Innovate

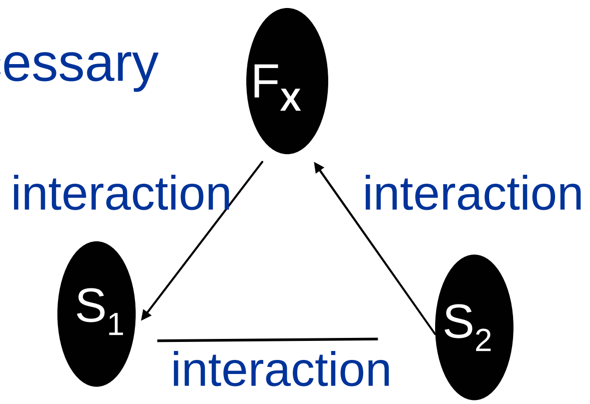
Standard Solution

Add the missing element of the model: F_X, S_1, or S_2
Explore each field: Me, E, Th, Ch, M, EM, or N



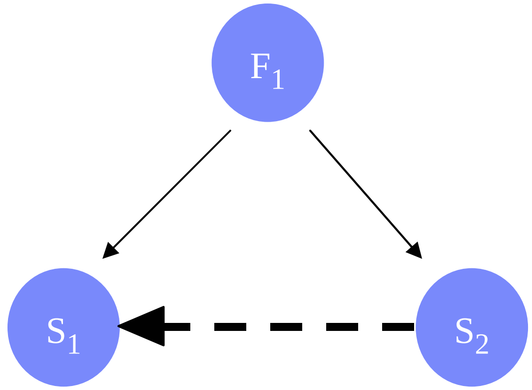
Incomplete, Insufficient, or Systems with Harm

- The minimum functioning system model involves a complete triad: F_X, S_1, S_2, and each interaction (3 minimum)
  - A system that contains at least one insufficient interaction is an insufficient system
  - An insufficient system should be made sufficient by adding the necessary elements to resolve the insufficiency



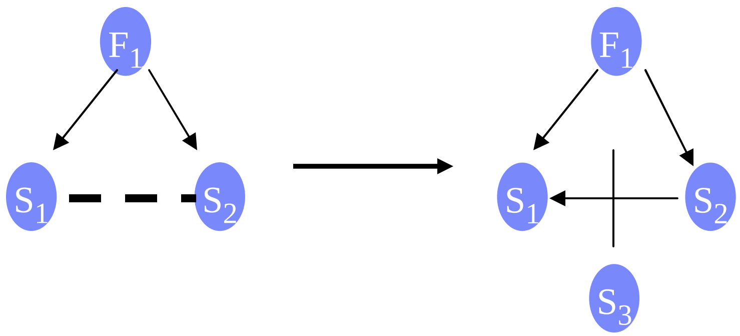
Insufficient Model

An insufficient model reflects a situation where all three elements are in place, but the useful field (F) is not sufficient



Standard Solution

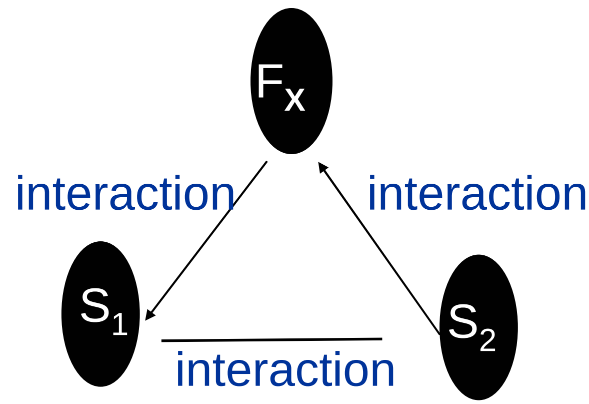
Insert a substance (S3) which is a modification of S1 or S2 or both that causes the interaction to become sufficient



Simplify, Perfect, Innovate

Incomplete, Insufficient, or Systems with Harm

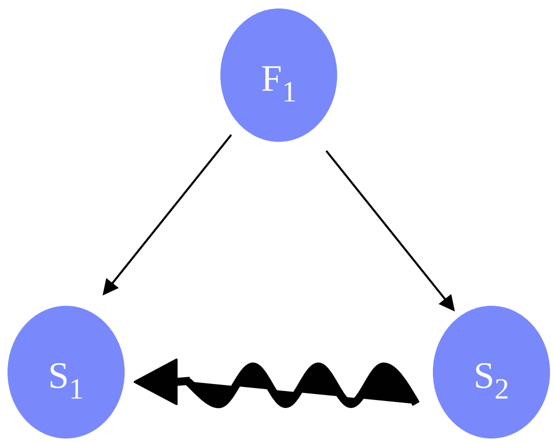
- The minimum functioning system model involves a complete triad: F_X, S_1, S_2, and each interaction (3 minimum)
  - A system that contains at least one harmful interaction is a system with harm
  - A system with harm should be made to have no harm



Simplify, Perfect, Innovate

System with Harm

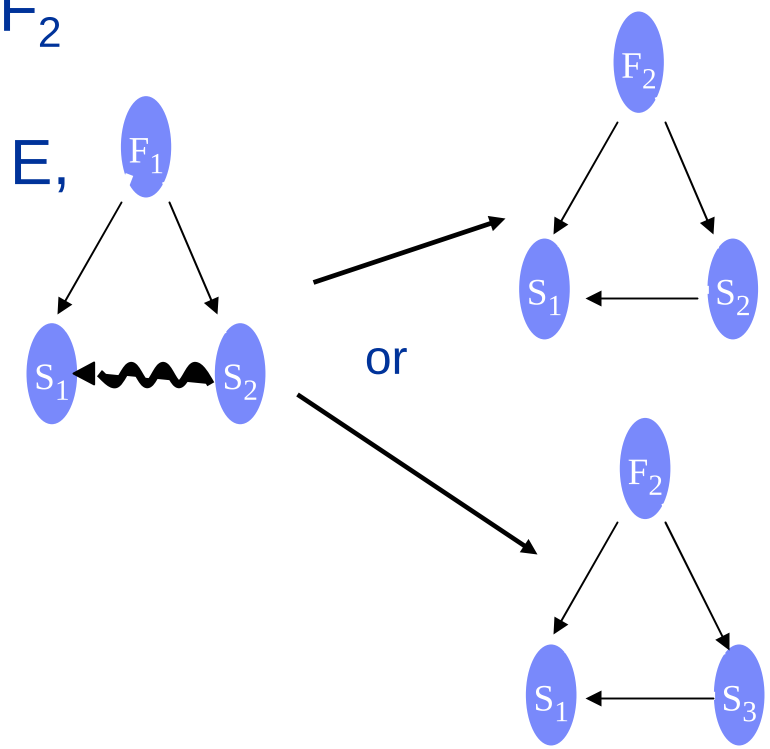
All three elements are in place, but the interaction between S1 and S2 is harmful or undesired or F_1 is harmful



Standard Solution

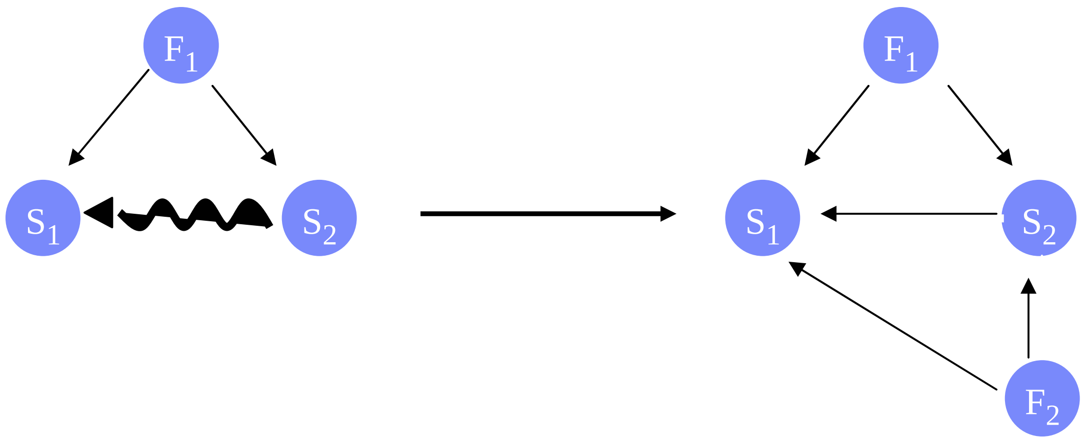
Replace F_1 (or F_1 and S_2) with another set: F_2 or (F_2 and S_3)

Explore each field: Me, E, Th, Ch, M, EM, or N



Standard Solution

Add another field (F_2) to intensify the desired effect
Explore each field: Me, E, Th, Ch, M, EM, or N



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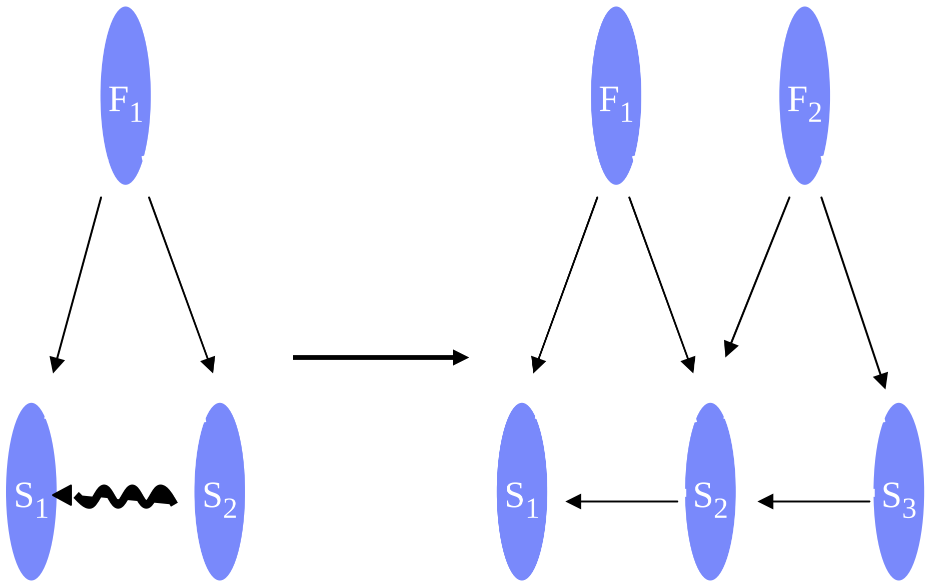
Simplify, Perfect, Innovate

Standard Solution

Insert a substance (S_3) and add another field (F_2). S_3 and F_2 enhance the desired effect

Explore each field: Me, Th, Ch, E, M, EM, or N



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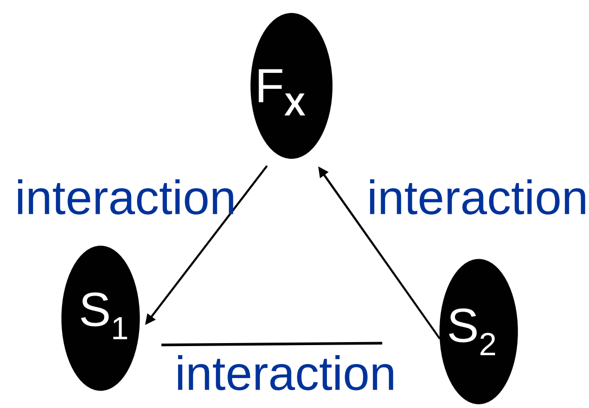
Simplify, Perfect, Innovate

Standards

- There is a body of standard solutions called the 76 Standard Solutions



The 76 Standard Solutions: 5 Classes

CLASS 1. COMPOSITION AND DECOMPOSITION OF SFMS
- GROUP 1-1: SYNTHESIS OF A SFM
- GROUP 1-2: DECOMPOSITION OF SFMS

CLASS 2. EVOLUTION OF SFMS
- GROUP 2-1: TRANSITION TO COMPLEX SFMS
- GROUP 2-2: EVOLUTION OF SFM
- GROUP 2-3: EVOLUTION BY COORINATING RHYTHMS
- GROUP 2-4: FE

CLASS 3. TRANSITIONS T
- GROUP 3-1: TR
- GROUP 3-2: TRANSITION TO MICROLEVEL

Notice that class 4 is focused on measurement and detection problems

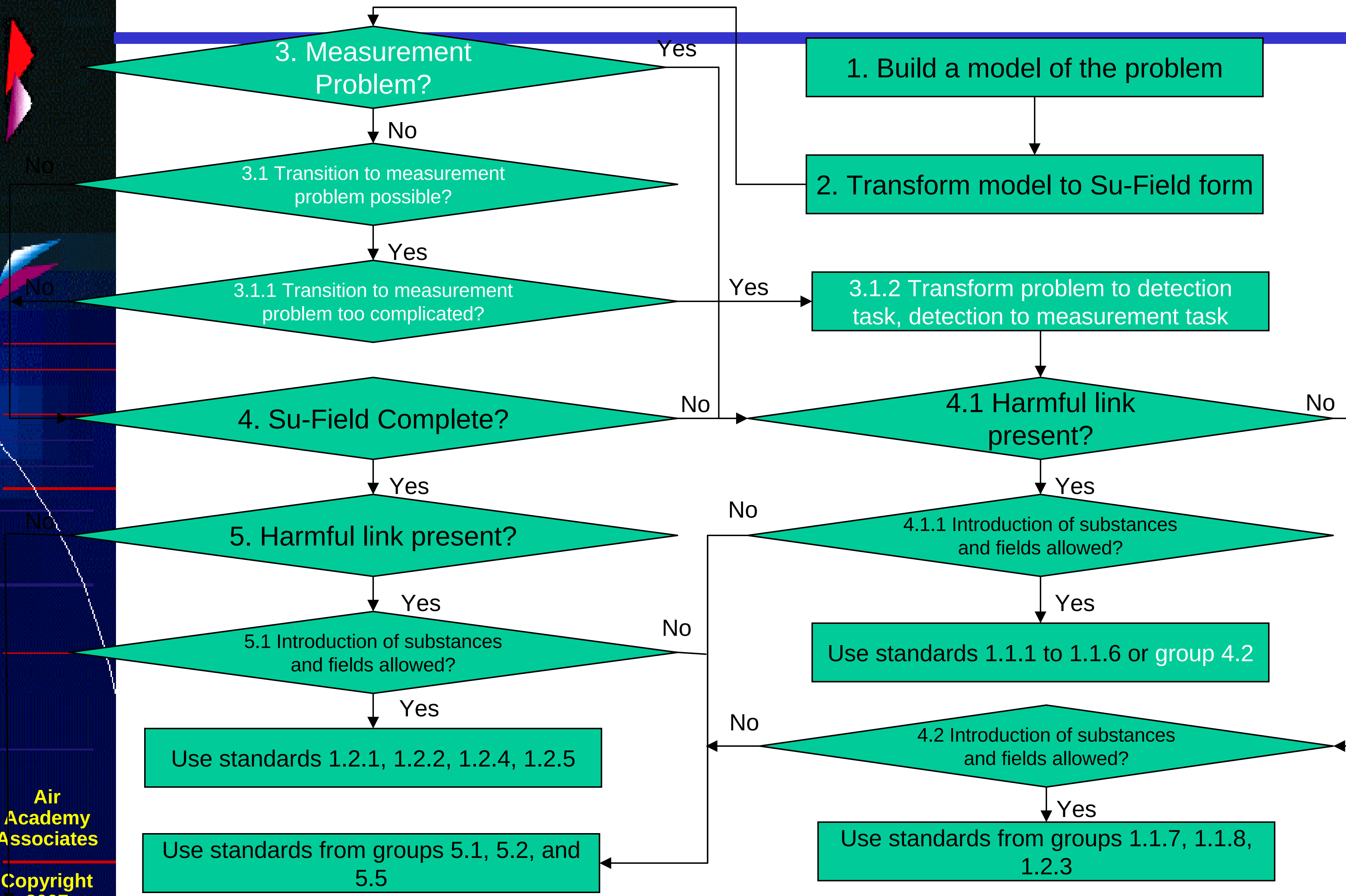
CLASS 4. MEASUREMENT AND DETECTION STANDARDS
- GROUP 4-1: INSTEAD OF MEASUREMENT AND DETECTION - SYSTEM CHANGE TO SOMETHING ELSE
- GROUP 4-2: SYNTHESIS OF A MEASUREMENT SYSTEM
- GROUP 4-3: ENHANCEMENT OF MEASUREMENT SYSTEMS
- GROUP 4-4: TRANSITION TO FERROMAGNETIC MEASUREMENT SYSTEM
- GROUP 4-5: EVOLUTION OF MEASUREMENT SYSTEMS

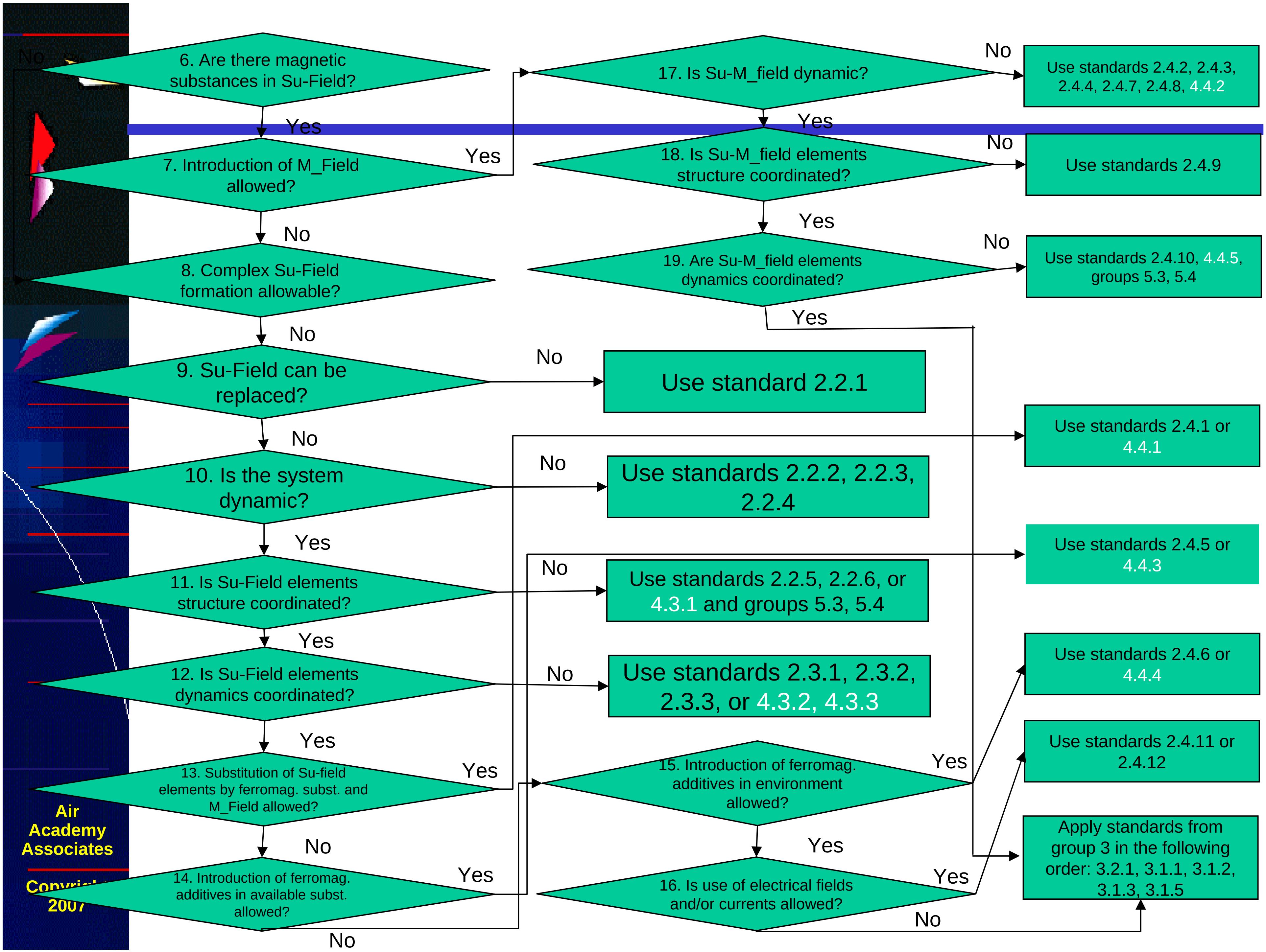
CLASS 5. SPECIAL RULES OF APPLICATION
- GROUP 5-1: SUBSTANCE INTRODUCTION
- GROUP 5-2: INTRODUCTION OF FIELDS
- GROUP 5-3: USE OF PHASE TRANSITIONS
- GROUP 5-4: PHYSICAL EFFECTS USE
- GROUP 5-5: SUBSTANCE PARTICLES OBTAINING

How Does it All Work?

- Identify the measurement and/or detection problem(s) in the system
- Create a SFM of the problem area(s)
- Analyze the SFMs for any deficiencies
  - Incomplete
  - Insufficient
  - Contains harm
- Utilize the SFM Algorithm to identify the appropriate solution standard(s)
- Apply standard solutions to create generic approaches for problem resolution
- Convert generic approach to specific solution using analogic thought

76 Standards Algorithm





6. Are there magnetic substances in Su-Field?
No
Yes
7. Introduction of M_Field allowed?
Yes
No
8. Complex Su-Field formation allowable?
No
9. Su-Field can be replaced?
No
Use standard 2.2.1
No
10. Is the system dynamic?
No
Use standards 2.2.2, 2.2.3, 2.2.4
Yes
11. Is Su-Field elements structure coordinated?
No
Use standards 2.2.5, 2.2.6, or 4.3.1 and groups 5.3, 5.4
Yes
12. Is Su-Field elements dynamics coordinated?
No
Use standards 2.3.1, 2.3.2, 2.3.3, or 4.3.2, 4.3.3
Yes
13. Substitution of Su-field elements by ferromag. subst. and M_Field allowed?
Yes
No
14. Introduction of ferromag. additives in available subst. allowed?
Yes
No
17. Is Su-M_field dynamic?
No
Use standards 2.4.2, 2.4.3, 2.4.4, 2.4.7, 2.4.8, 4.4.2
Yes
18. Is Su-M_field elements structure coordinated?
No
Use standards 2.4.9
Yes
19. Are Su-M_field elements dynamics coordinated?
No
Use standards 2.4.10, 4.4.5, groups 5.3, 5.4
Yes
Use standards 2.4.1 or 4.4.1
Use standards 2.4.5 or 4.4.3
Use standards 2.4.6 or 4.4.4
Use standards 2.4.11 or 2.4.12
Apply standards from group 3 in the following order: 3.2.1, 3.1.1, 3.1.2, 3.1.3, 3.1.5
15. Introduction of ferromag. additives in environment allowed?
Yes
Yes
16. Is use of electrical fields and/or currents allowed?
Yes
No
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Conclusions

- Problem solving may often include the need for the collection of information from the system in question
  – Measure phase of DMAIC
- Collecting this information can be its’ own problem
- The TRIZ methodology provides techniques specifically designed to resolve measurement and detection problems
  – Su-field Mode (SFM)
  – 76 Standard Solutions
  – SFM Algorithm

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Measurement and Detection Standards from the TRIZ Methodology

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Air Academy Associates

CLASS 4. MEASUREMENT AND DETECTION STANDARDS

Class 4 Standards with Examples

STANDARD 4-1-1

If a problem involves detection or measurement, it is proposed to change the problem in such a way, so that there should be no need to perform detection of measurement at all.

Example: **To prevent a permanent electric motor from overheating, its temperature is measured by a temperature sensor. If to make the poles of the motor of an alloy with a Curie point equal to the critical value of the temperature, the motor will stop itself.**

STANDARD 4-1-2

If a problem involves detection of measurement, and it is impossible to change the problem to eliminate the need for detection or measurement, it is proposed to change/detect properties of a copy of the object (e.g. picture).

Example: **It might be dangerous to measure the length of a snake. It is safe to measure its length on a photographic image of the snake, and then recalculate the obtained result.**

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-3

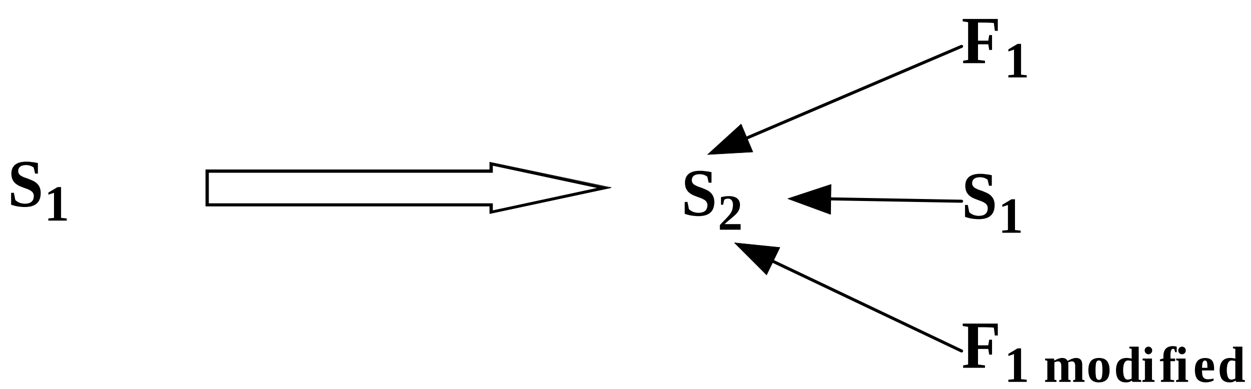
If a problem involves detection or measurement, and the problem cannot be changed to eliminate the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into a problem of successive detection of changes.

Notes: Any measurement is conducted with a certain degree of accuracy. Therefore, even if the problem deals with continuous measurement, one can always single out a simple act of measurement that involves two successive detections. This makes the problem much simpler.

Example: **To measure a temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.**

STANDARD 4-2-1

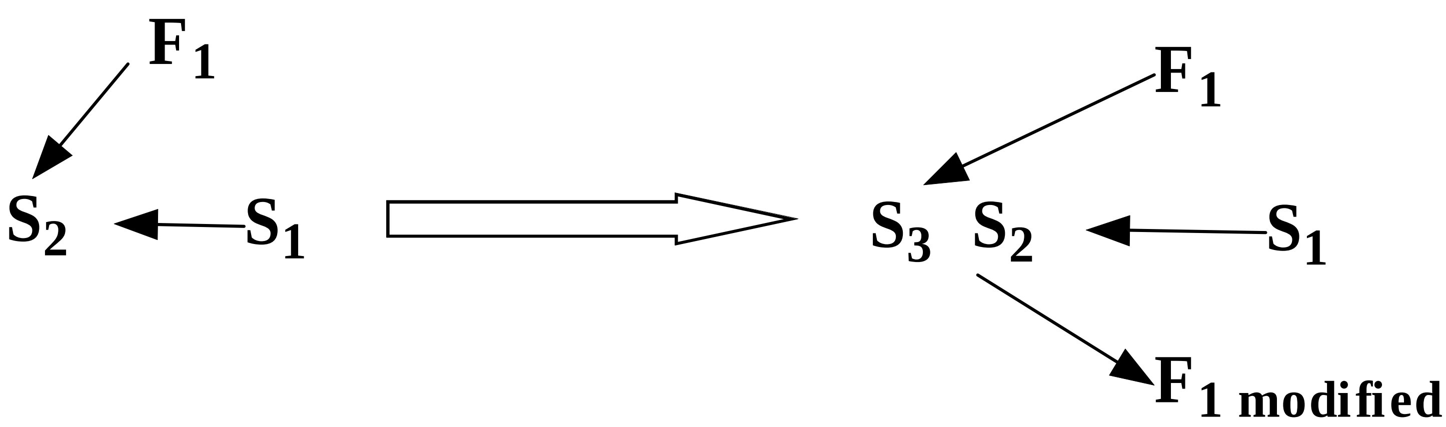
If a non-SFM is not easy to detect or measure, the problem is solved by synthesizing a simple or dual SFM with a field at the output. Instead of direct measurement or detection of a parameter, another parameter identified with the field is measured or detected. The field to be introduced should have a parameter that we can easily detect or measure, and which can indicate the state of the parameter we need to detect or measure.



Example: To detect a moment when liquid starts to boil, an electrical current is passed through the liquid. During boiling, air bubbles are formed - they dramatically reduce electrical resistance of the liquid.

STANDARD 4-2-2

If a system (or its part) does not provide detection or measurement, the problem is solved by transition to an internal or external complex measuring SFM, introducing easily detectable additives.



Example: To detect leakage in a refrigerator, a cooling agent is mixed with a luminescent powder.

STANDARD 4-2-3

If a system is difficult to detect or to measure at a given moment of time, and it is not allowed or not possible to introduce additives into the object, then additives that create an easily detectable and measurable field should be introduced in the external environment. Changing the state of the environment will indicate the state of the object.

Example: **To detect wearing of a rotating metal disc contacting with another disc, it is proposed to introduce luminescent powder into the oil lubricant, which already exists in the system. Metal particles collecting in the oil will reduce luminosity of the oil.**

STANDARD 4-2-4

If it is impossible to introduce easily detectable additives in the external environment, these can be obtained in the environment itself, for instance, by decomposing the environment or by changing the aggregate state of the environment.

Notes: In particular, gas or vapor bubbles produced by electrolysis, cavitation or by any other method may often be used as additives obtained by decomposing the external environment.

Example: **The speed of a water flow in a pipe might be measured by amount of air bubbles resulting from cavitation.**

STANDARD 4-3-1

Efficiency of measuring SFM can be improved by the use of physical effects.

Example: **Temperature of liquid media can be measured by measuring a change of a coefficient of retraction, which depends on the value of the temperature.**

STANDARD 4-3-2

If it is impossible to detect or measure directly the changes in the system, and no field can be passed through the system, the problem can be solved by exciting resonance oscillations (of the entire system or of its part), whose frequency change is an indication of the changes taking place.

Example: **To measure the mass of a substance in a container, the container is subjected to mechanically forced resonance oscillations. The frequency of the oscillations depends on the mass of the system.**

STANDARD 4-3-3

If resonance oscillations may not be excited in a system, its state can be determined by a change in the natural frequency of the object (external environment) connected with the system.

Example: **The mass of boiling liquid can be measured by measuring the natural frequency of gas resulting form evaporation.**

STANDARD 4-4-1

Efficiency of a measuring SFM can be improved by using a ferromagnetic substance and a magnetic field.

Notes: The standard indicates the use of a non-fragmented ferromagnetic object.

STANDARD 4-4-2

Efficiency of detection or measurement can be improved by transition to ferromagnetic SFMs, replacing one of the substances with ferromagnetic particles (or adding ferromagnetic particles) and by detecting or measuring the magnetic field.

STANDARD 4-4-3

If it is required to improve the efficiency of detection or measurement by transition to a ferromagnetic SFM, and replacement of the substance with ferromagnetic particles is not allowed, the transition to the F-SFM is performed by synthesizing a complex ferromagnetic SFM, introducing (or attaching) ferromagnetic additives in the substance.

STANDARD 4-4-4

If it is required to improve efficiency of detection or measurement by transition to F-SFM, and introduction of ferromagnetic particles is not allowed, ferromagnetic particles are introduced in the external environment.

STANDARD 4-4-5

Efficiency of a F-SFM measuring system can be improved by using physical effects, for instance, Curie point, Hopkins and Barkhausen effects, magneto-elastic effect, etc.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-5: Evolution of Measurement Systems

STANDARD 4-5-1

Efficiency of a measuring system at any stage of its evolution can be improved by forming bi- and poly-system.

Notes: To form bi- and poly-systems, two or more components are combined. The components to be combined may be substances, fields, substance-field pairs and SFMs.

Example: **It is difficult to accurately measure the temperature of a small beetle. However, if there are many beetles put together, the temperature can be measured easily.**

STANDARD 4-5-2

Measuring systems evolve towards measuring the derivatives of the function under control. The transition is performed along the following line:

Measurement of a function $\rightarrow$ measurement of the first derivative of the function $\rightarrow$ measurement of the second derivative of the function.

Example: **Change of stress in the rock is defined by the speed of changing the electrical resistance of the rock.**

Early Application of Computer Program Systems Integration, Test and Performance Measurement

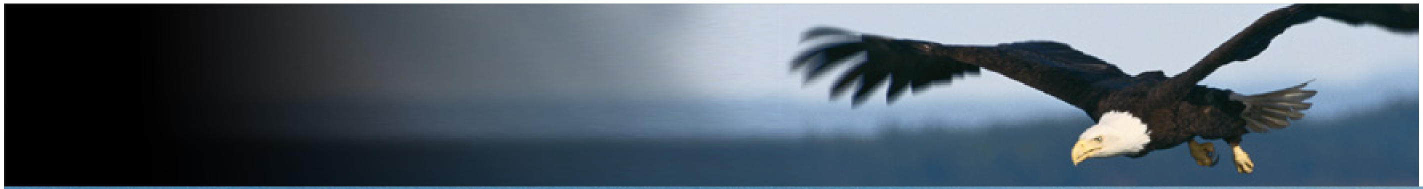
Tom Sobieralski
Computer Sciences Corporation

NDIA National Test and Evaluation Conference
March 12-15, 2007

EXPERIENCE. RESULTS.

Agenda

- Background
- Systems Integration, Test and Performance Measurement
- Summary



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Background

What is Computer Program Systems Integration, Test and Performance Measurement?

- The ability to verify the interfaces, functions and measure performance of two or more computer programs on the target hardware suite and operating environment.

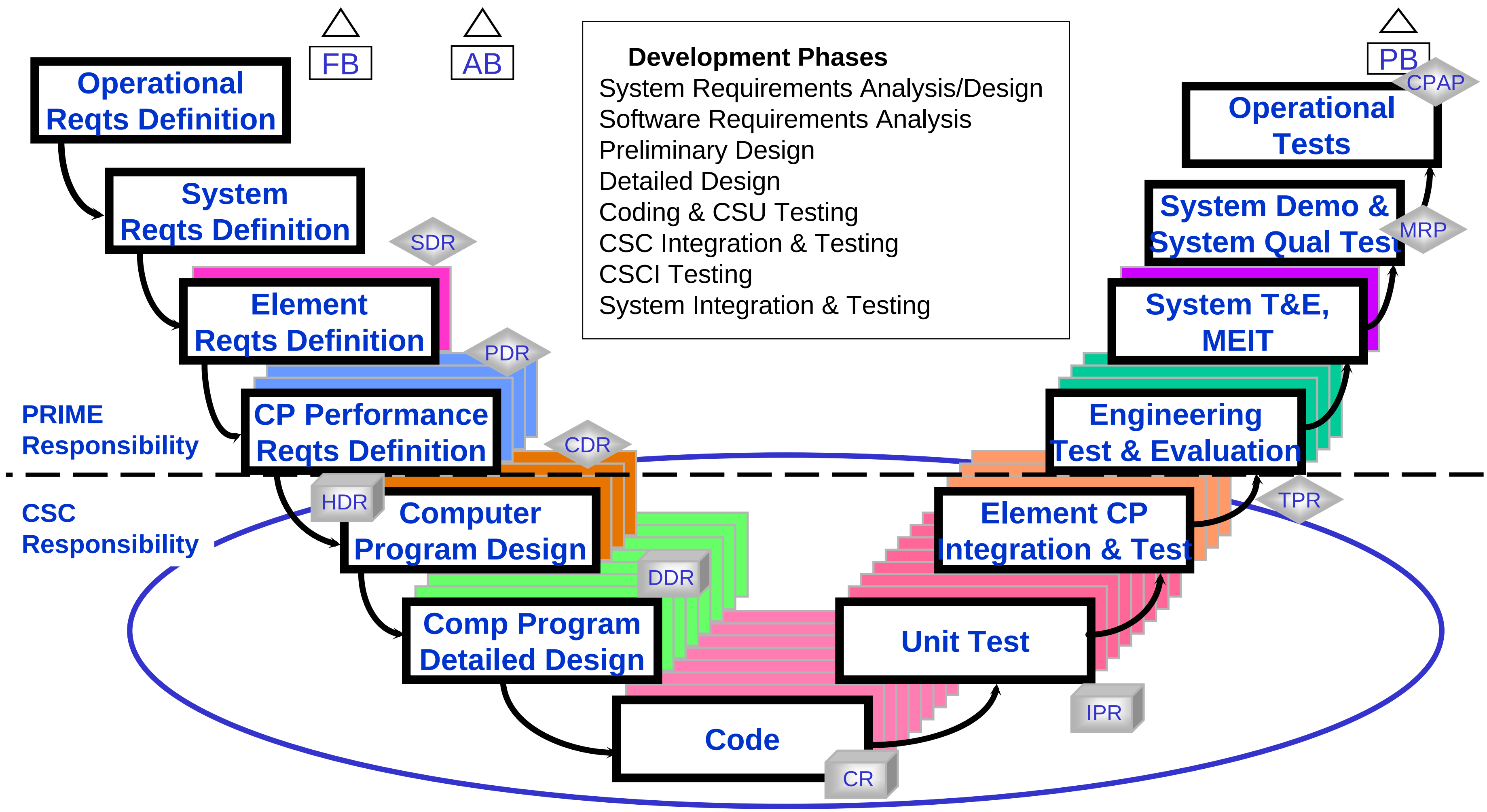
Catalyst for Early Computer Program Systems Integration, Test and Performance Measurement

- Introduction of COTS hardware
- Conversion of legacy software to new languages
- System complexity with multiple hardware and operating environments

CSC EXPERIENCE. RESULTS.

Software Development Process

System Definition & Design	Computer Program Definition & Design	Computer Program Implementation	Computer Program Testing	System Integration Testing



Multi-Processor Environments

- Legacy
  - AN/UYKs
- COTS Processors
  - Single Board Computers (SBCs)
  - Symetric Multi-Processors (SMPs)

AN/UYK-43

COTS Processor Cabinet

Operator Console

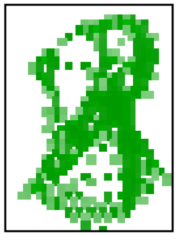
User Display Console

Multi-Operating Environments

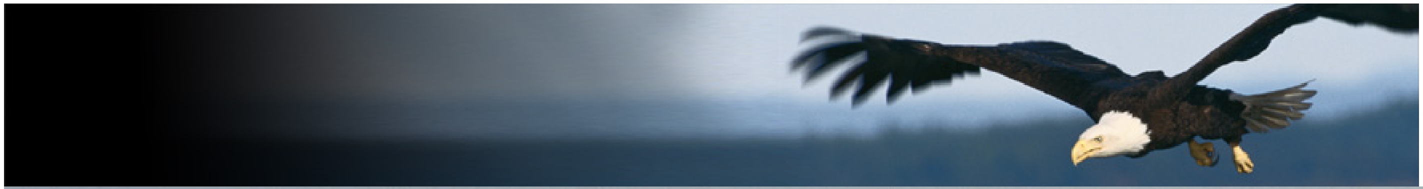
- Legacy
  - Aegis Tactical Executive System (ATES)
- COTS
  - Concurrent Powermax
  - Sun Solaris
  - Red Hawk Linux
  - LynxOS

Multi-Computer Programming Languages

- Legacy
  - Compiler Monitor System -2 (CMS-2)
- New
  - Ada
  - C/C++
  - Java



C/C++



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Systems Integration, Test and Performance Measurement

Process Improvement

- Incremental Systems Integration, Test and Performance Measurement during the software development process
  - Improve System Stability
  - Early Identification and Resolution of issues and defects
  - Significantly reduce Engineering Test & Evaluation failure rates
  - Processes and Procedures QA reviewed and approved

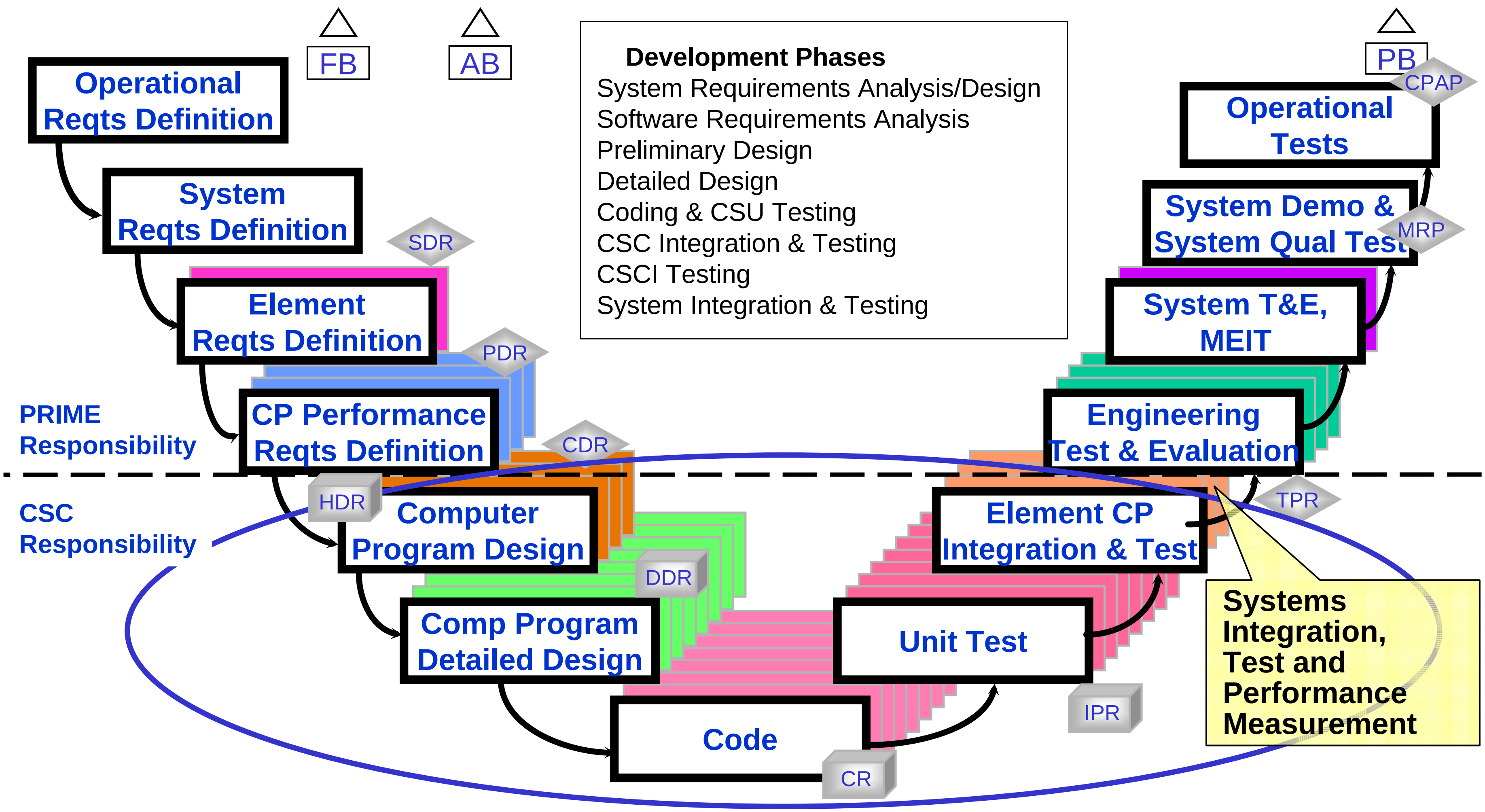
CMMI®

CSC DMEI DE CMMI Level 5

CSC EXPERIENCE. RESULTS.

Software Development Process

System Definition & Design	Computer Program Definition & Design	Computer Program Implementation	Computer Program Testing	System Integration Testing



Systems Integration

- Validate and maintain operability of system hardware and operating environments
- Verify Computer Program Interfaces

Hardware, OE, Computer Program Interface issues resolved during the computer program development phase

Systems Integration continued

- Integration issues tracking and reporting
  - Integration Issue resolution prior to computer program delivery

SYSTEMS INTEGRATION & TEST					
		BUILD ISSUES FOUND	ISSUES CLOSED DURING BUILD	DEFECTS WHICH BECAME TORs	ACTIVE ISSUES BEING ADDRESSED
BUILDS					
Build 4		18	15	3	0
Build 5		53	37	16	0
Totals		71	52	19	0

Systems Test

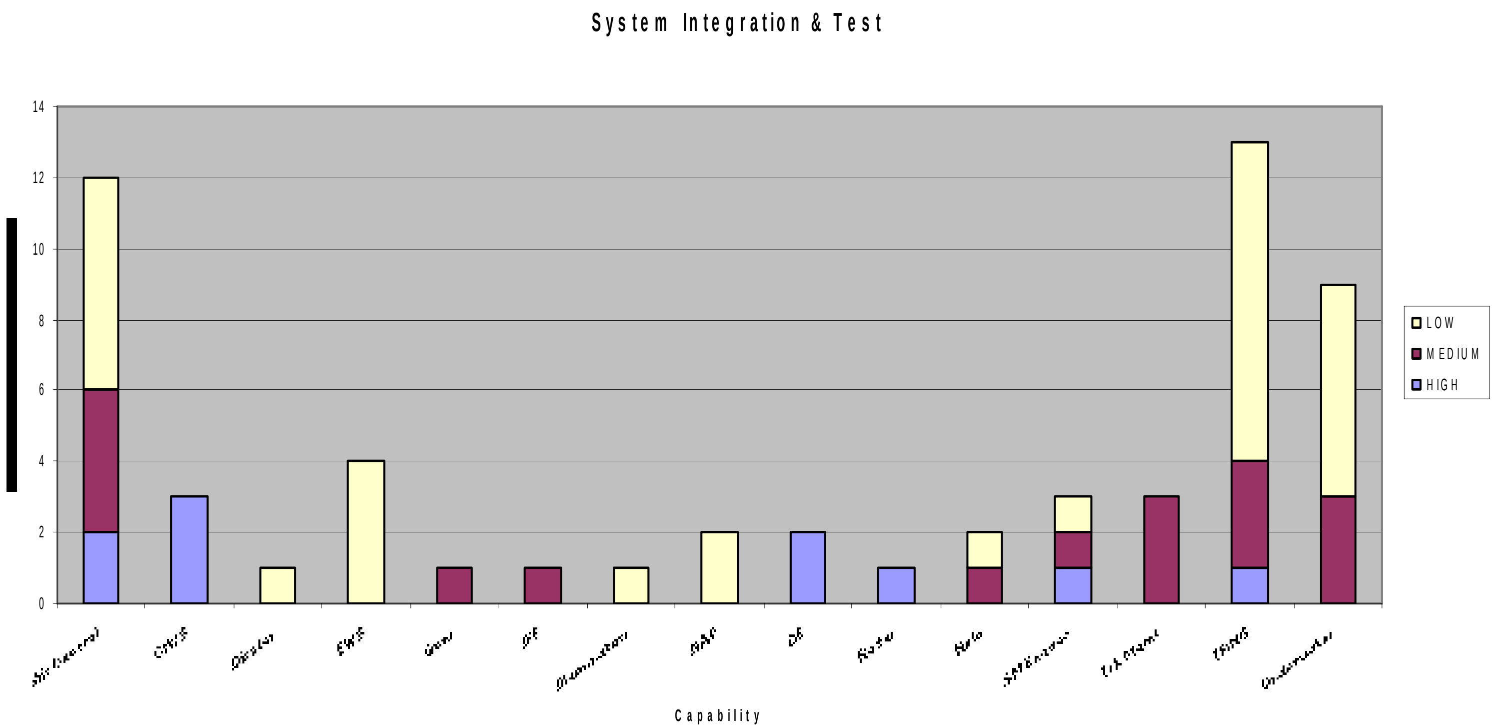
- Development and Regression Functional Testing
  - Documentation
    - Plans
    - Procedures
  - Execution
    - Utilizing two or more computer programs
      - Multiple hardware and operating environments

5% to 10% Improvement of Engineering Test & Evaluation

EXPERIENCE. RESULTS.

Systems Test continued

- Test defect reporting and tracking
  - Test defect resolution prior to computer program delivery



EXPERIENCE. RESULTS.

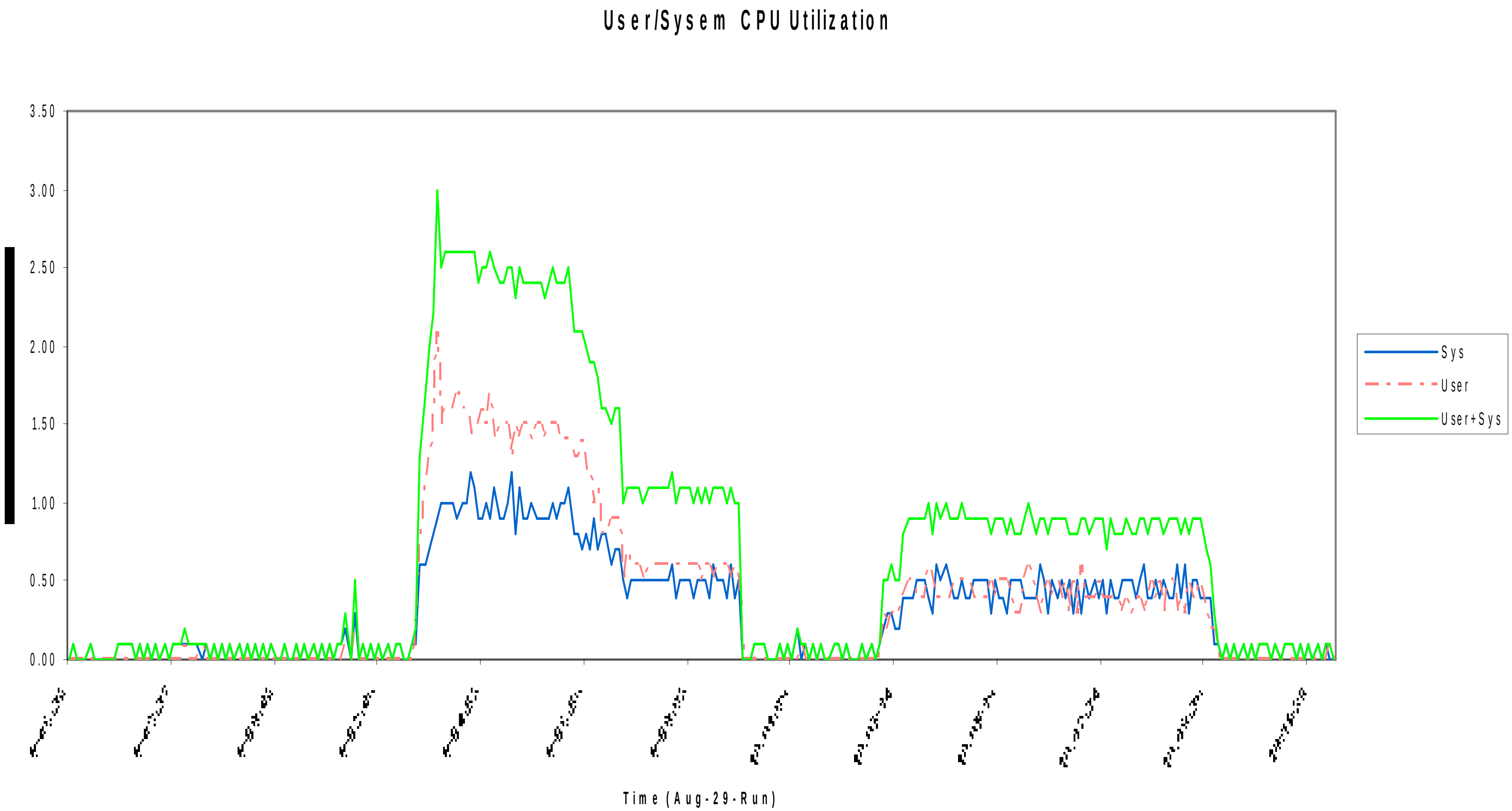
Systems Performance Measurement

- CPU and Memory Utilization
- Thread and Response Timing
- Measurement Tools
  - Legacy
    - ATES Data Recording
  - COTS
    - UNIX TOP and Kernel Trace
    - Concurrent Nightview
    - LynxOS Spyker
- Standard scenario
  - Function and information loading
  - Repeatable

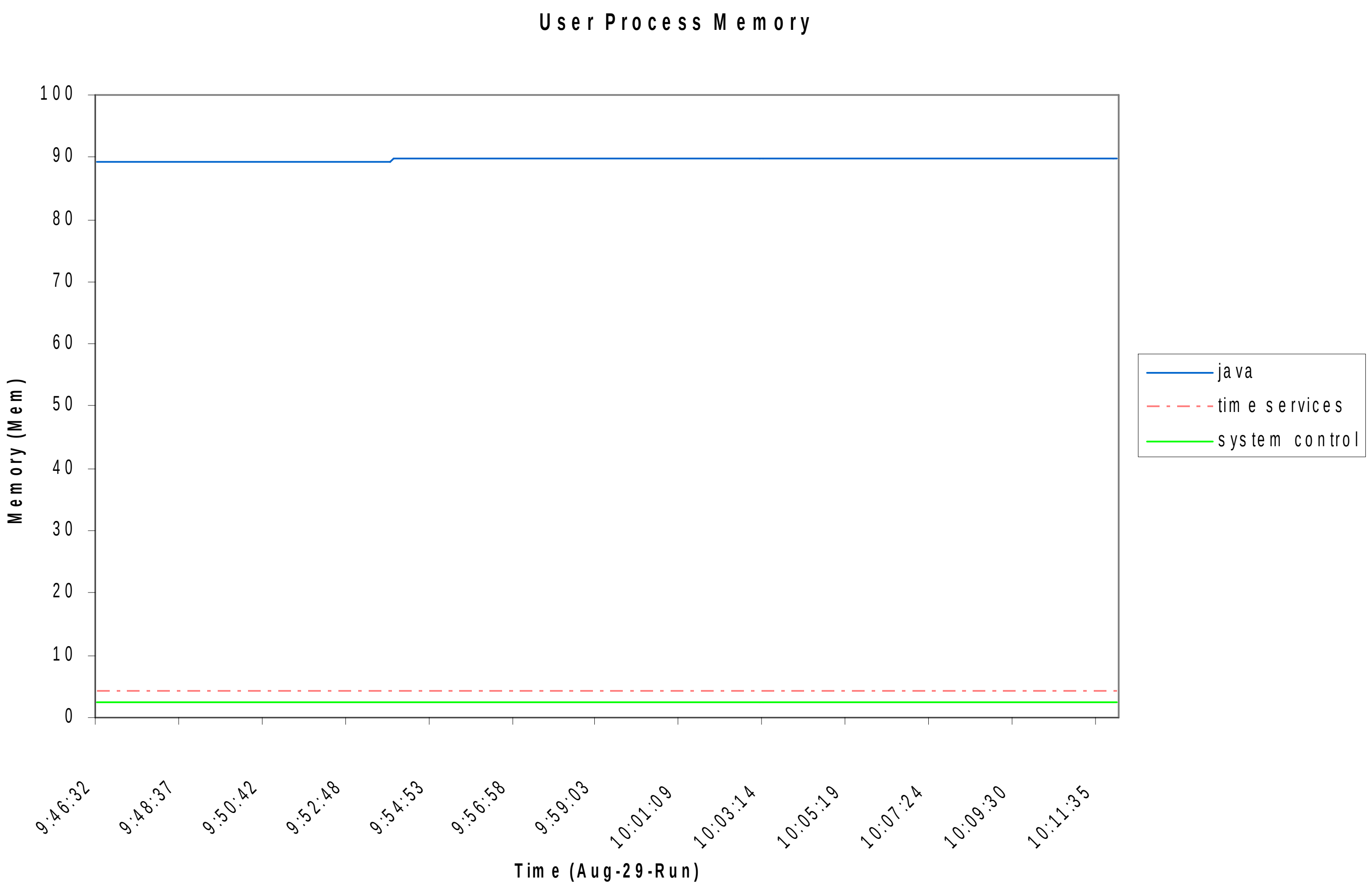
Systems Performance Measurement continued

- Performance Measurement Abnormalities
  - CPU and Memory Utilization Increase
  - CPU Utilization Spikes
  - Memory Leaks
  - Slow Thread or Response

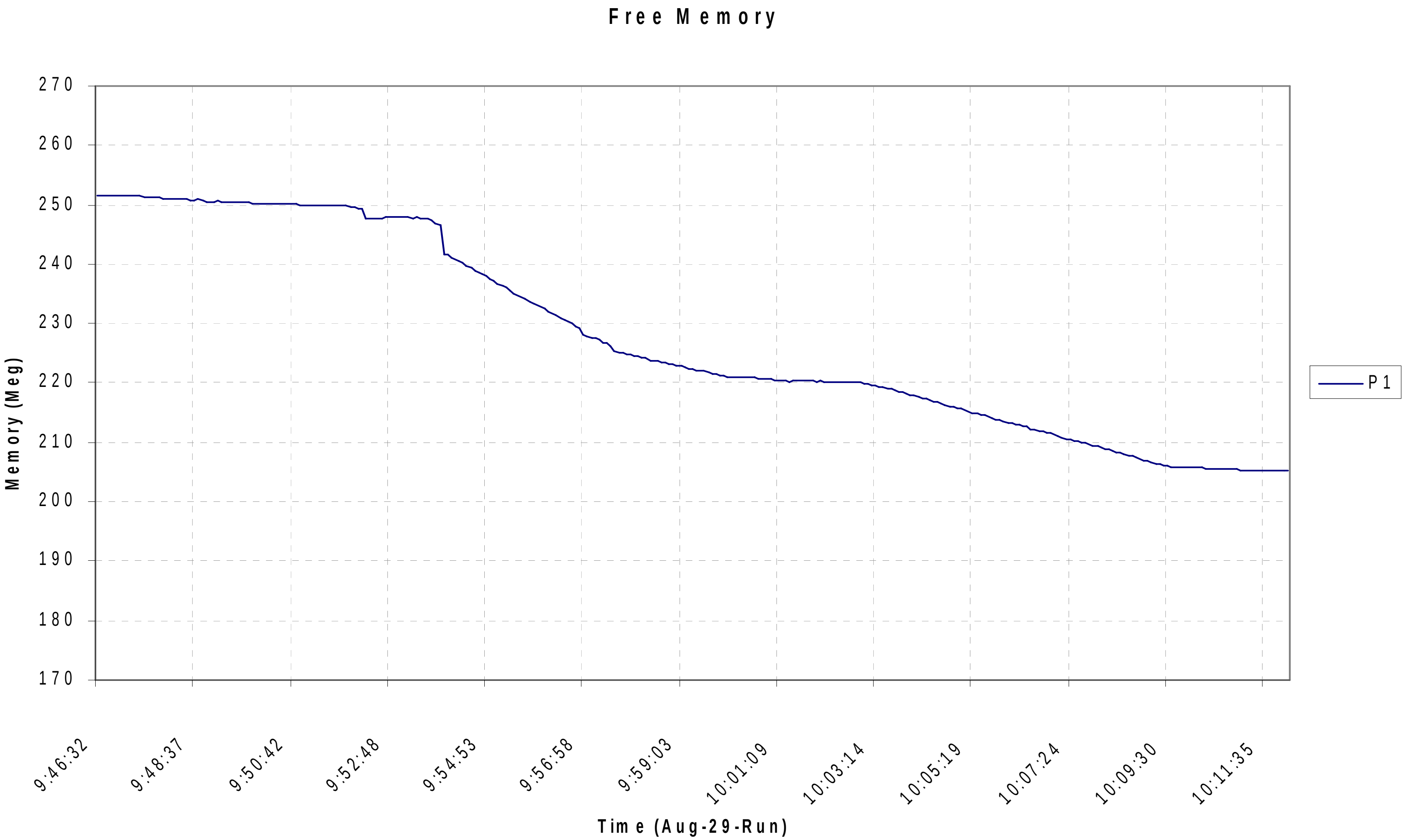
Systems Performance Measurement – CPU Utilization



Systems Performance Measurement – Memory Utilization



Systems Performance Measurement – Memory Leak



EXPERIENCE. RESULTS.

Systems Performance Measurement continued

- Performance Measurement issues resolved before computer program delivery

10% to 20% CPU Utilization Improvement

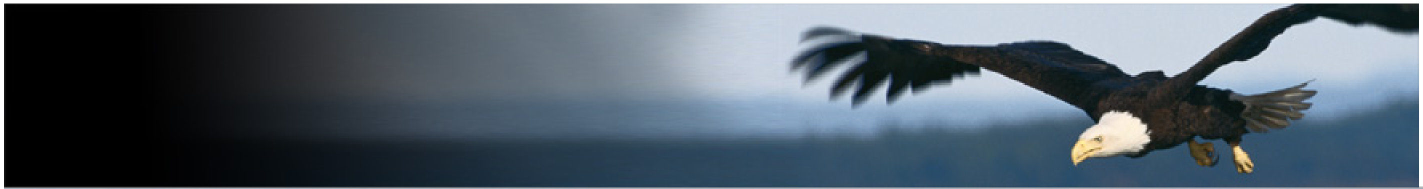
CSC

EXPERIENCE. RESULTS.

Summary

- Incremental Systems Integration, Test and Performance Measurement
- Integration and Test issue and defect resolution during the computer program development phase
- Improved Computer Systems Stability and Performance

Cost Effective by identifying and resolving systems issues and defects during the computer program development phase



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- Panel -

Systems Engineering and DT&E for Systems Suitability

Colonel Rich Stuckey

Principal Assistant for DT&E

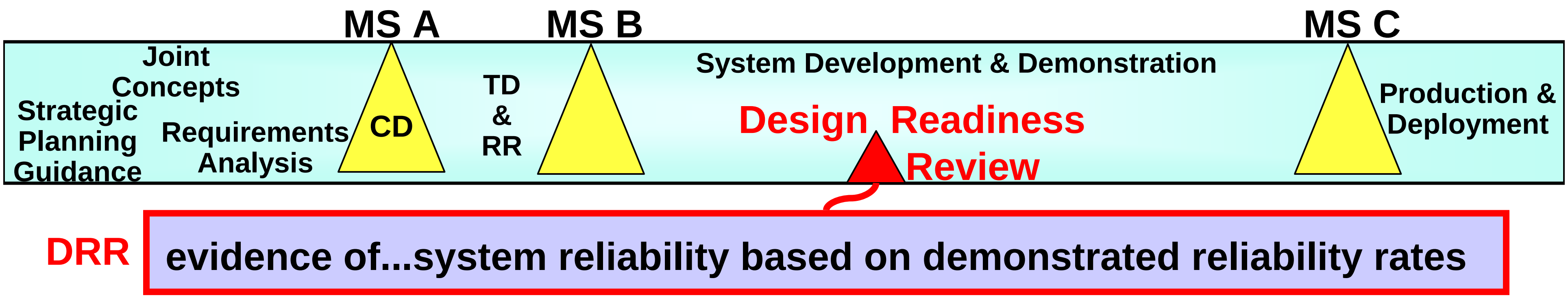
OUSD(AT&L) Systems and Software Engineering

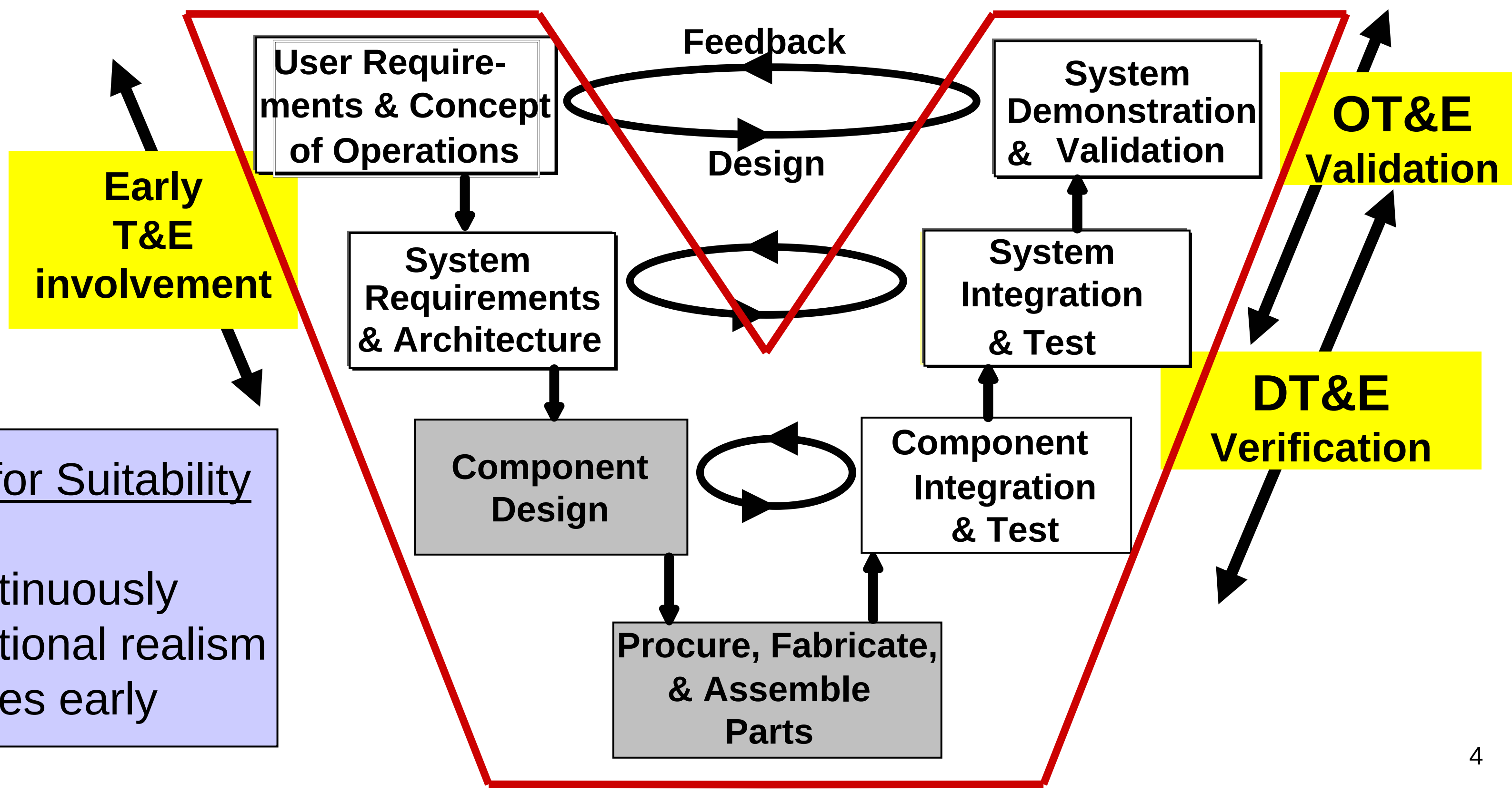
DT&E and suitability…do we have a problem?

Systemic DT&E Findings
OSD Program Support Reviews

- Maturing suitability in SDD is not a priority
  - Few efforts observed to design-in reliability
  - Many reliability requirements lack a mission context
  - Maturation timeframes or maturity at IOC not defined in requirements
  - Log Demos to evaluate IETMs and diagnostics effectiveness rarely held
    - Log demos in PD phase are conducted too close to IOT&E
- Most programs lack quantifiable MS C entrance criteria
  - Don't address R&M, manufacturing, integration, Net Ready, etc.
- Many programs downgraded ACAT ID to ACAT IC at MS C
  - Not supported by demonstration of full capabilities, including suitability

SE, DT&E and Suitability





<u>Concepts for Suitability</u>

- Start early
- Focus continuously
- Add operational realism
- Raise issues early

DOD Guide for Achieving Reliability, Availability, and Maintainability

http://www.acq.osd.mil/se/publications/pig/RAM%20Guide%20(080305).pdf

DOD GUIDE FOR ACHIEVING

RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

"Systems Engineering for Mission Success"

AUGUST 3, 2005

Panel Format

1. Initial remarks by each panelist

2. Panel Q&A

- Moderator asks Q
- 1 panelist takes initial A - no time limit
- Panelist fire-at-will after initial A
- Moderator calls time at ~8 minutes

Panelists

- **Dr. David M. Jerome**

  Deputy Director of Air, Space and Information Operations

  Headquarters, Air Force Materiel Command

- **Mr. Richard L. Schubert**

  Vice President and Chief Engineer

  Lockheed Martin's Integrated Systems and Solutions

- **Mr. Brian M. Simmons**

  Director, US Army Evaluation Center

- **Mr. Ray Lytle**

  Director of Life Cycle Engineering

  Raytheon Missile Systems

Question 1

How well do the systems being fielded in Iraq meet their sustainability expectations?

Question 2

How do we resolve the conundrum:

- The user drives rapid fielding ("tyranny of the urgent");
- But DOT&E raises the issue of sustainability, while rapid fielding bypasses a disciplined approach to suitability.

Question 3

Do system requirements sufficiently address sustainment?

Question 4

How could we modify traditional DT & OT processes to improve sustainment? (and, how to evolve DT/OT to fit the rapid fielding process)?

Question 5

How is DT&E for software different from hardware for the suitability, effectiveness and sustainability arena?

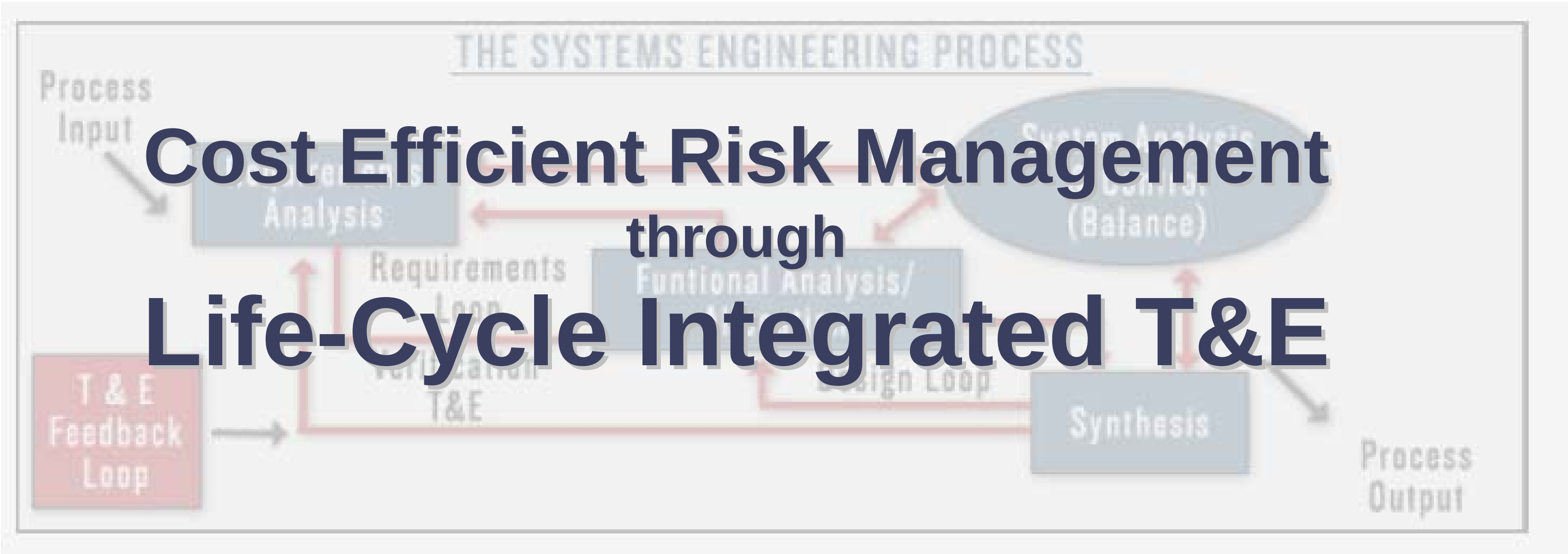
Question 6

Can we link M&S used in suitability analyses, with M&S used in system performance analyses, so more complete and early decisions can be made for systems engineering?

Question 7

Do system development contracts instruct industry sufficiently to design & deliver sustainability?

23rd Annual NDIA Test and Evaluation Conference
March 12-15, 2007, Hilton Head, SC



Cost Efficient Risk Management
through
Life-Cycle Integrated T&E

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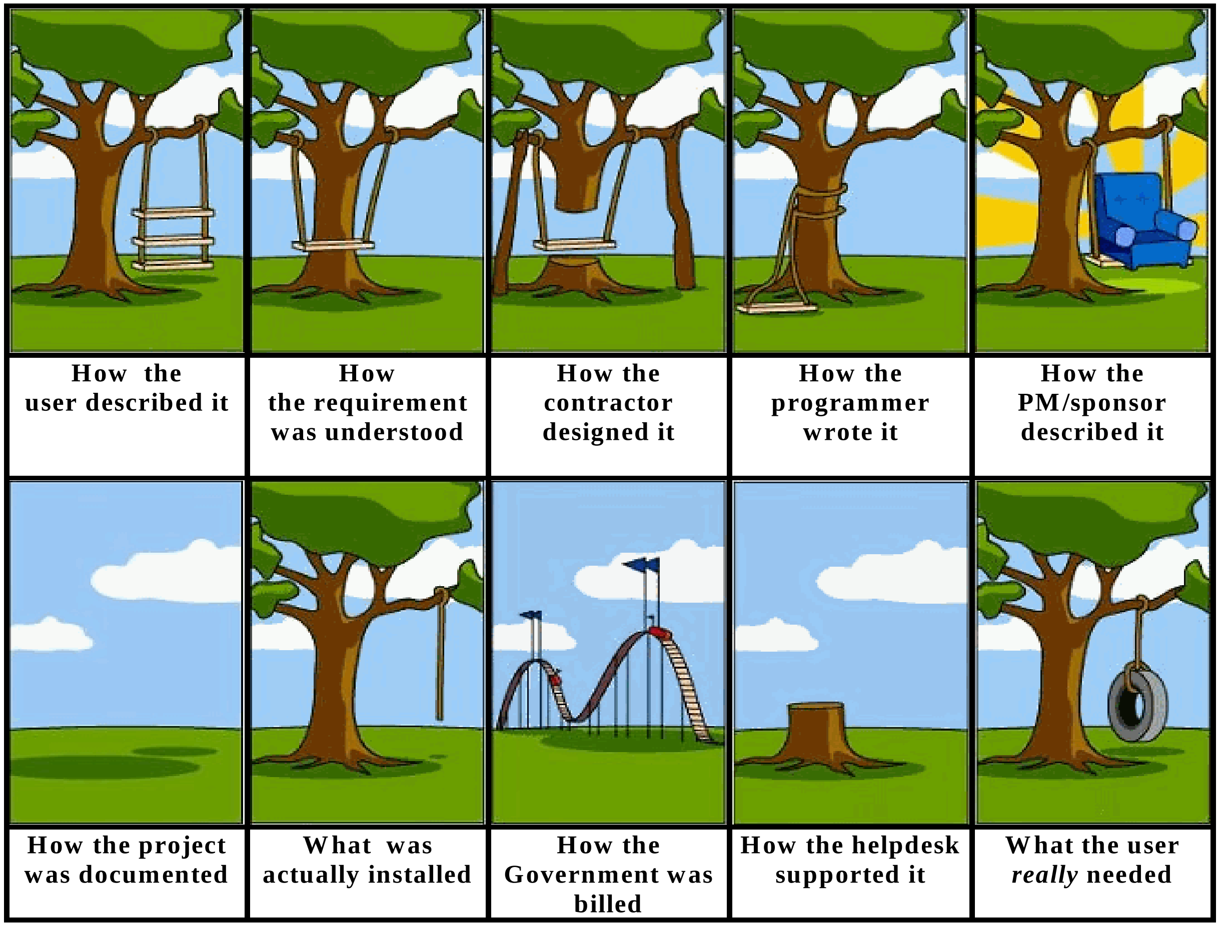
Agenda

- Introduction
  - Acquisition humor
  - Complexity challenge = increasing risk
  - Intro to Integrated T&E
- Integrated T&E within systems engineering to manage risk
  - Alignment of T&E processes within systems engineering process
  - Integration of T&E organizations/processes throughout acquisition life cycle
- Enablers to implement IT&E within a program
  - Risk based T&E planning and reporting
  - AVW IT&E Database Toolset
  - Other recommendations for implementing IT&E
- Conclusion/ Q&A

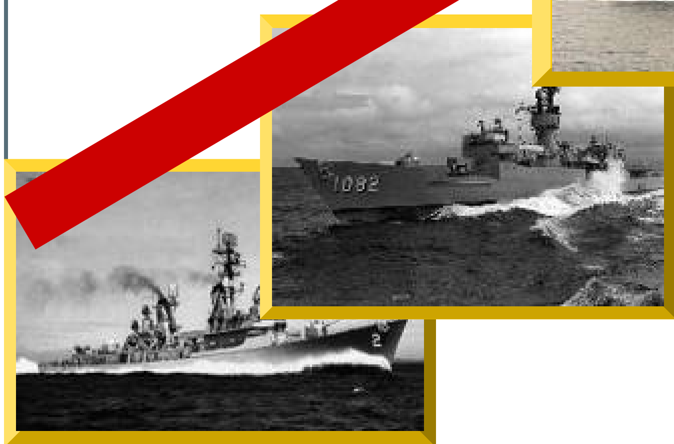
NOTE: My remarks are intended to spur thought on improving how we as testers can do business better to support the warfighter. While I hope this aligns well with DoD and Services T&E initiatives, I am not representing any government agencies' official position.

Acquisition 101?



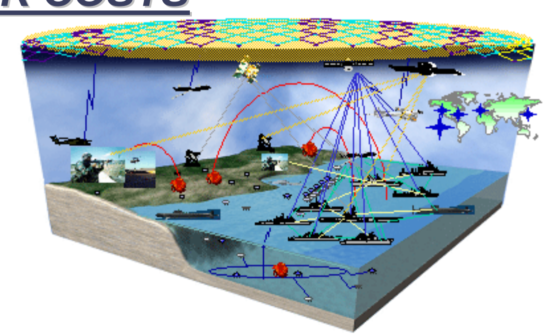
How do we avoid this?

Complexity Challenge

- Open Architecture/Systems
- Complex C4I—GIG/FORCEnet
- Joint Interoperability
- Emerging Technology & Materials
- Capabilities Based Requirements
- CAIV

- More difficult to develop
- More difficult to test
- Compressed timelines
- Compressed budgets
- ***<u>MORE RISK…& HIGHER COSTS</u>***



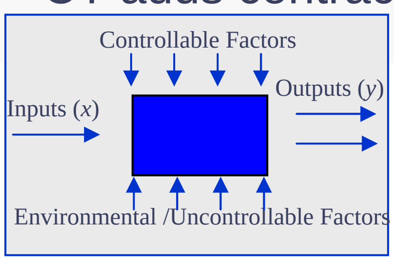
~~DT vs. OT~~ → IT

DT

- Test to specs.
- Limited test environment perhaps in lab
- Focused on a specific set of criteria.
- Test threshold values not capability
- Critical technical parameters
- Integration testing designed around minimum performance criteria and interface spec.
- May not address all threats or missions.
- CT adds contractual issues

OT

- Operational environment & threat with end users & support
- End-to-end mission perf. & support
- Production representative; system/ family of systems
- Test overall capability of an item to meet user's mission needs and value added for mission accomplishment.
- Test the limitations and capabilities of an item so that:
- Employ and assess doctrine/TTP
- Independent IOT&E & LFT&E mandates (Title X)

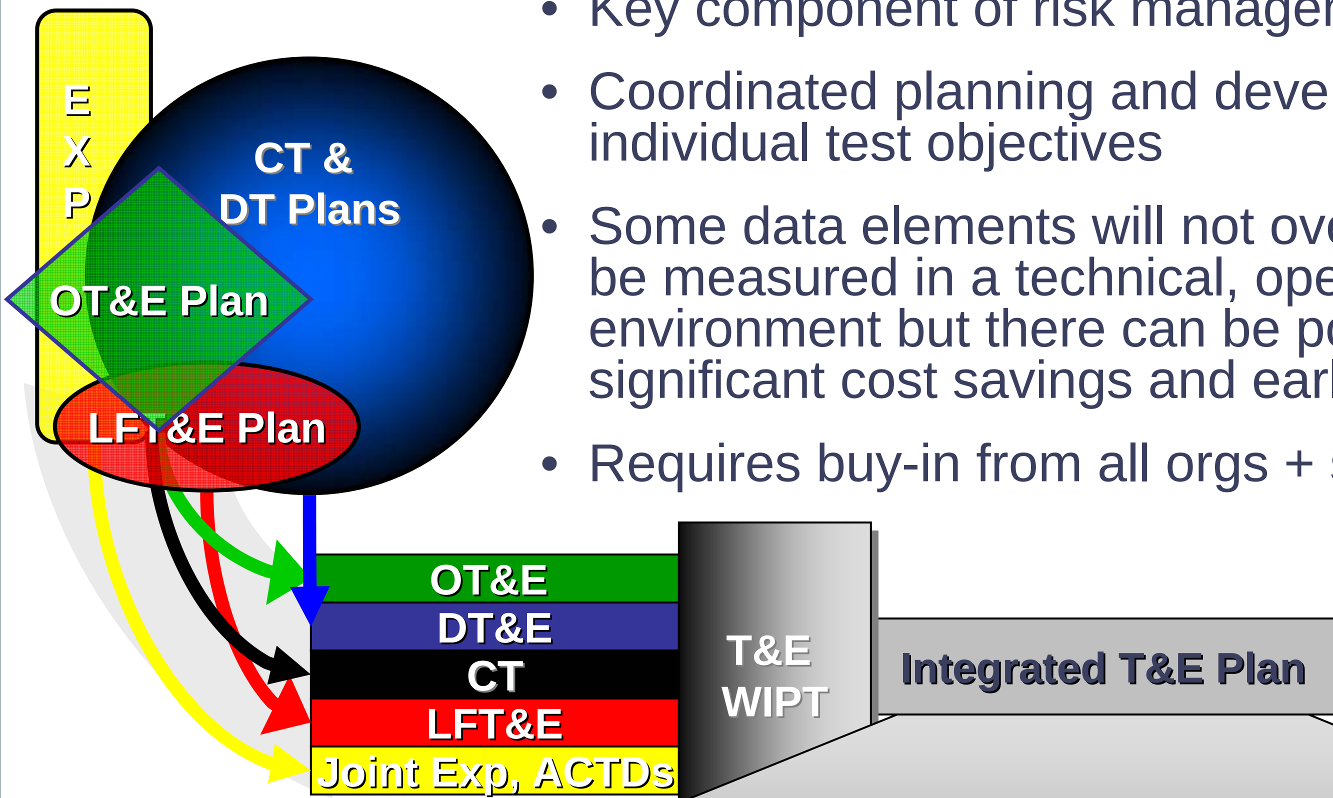


THIS MUST TRANSFORM INTO A
<u>CONTINUUM OF INTEGRATED TESTING</u>

- **Increasing fidelity of technical and operational assessments**
- **Cooperating organizations**
- **Reduced budget and timeline ?**
- **Team/IPT structure not competitive**

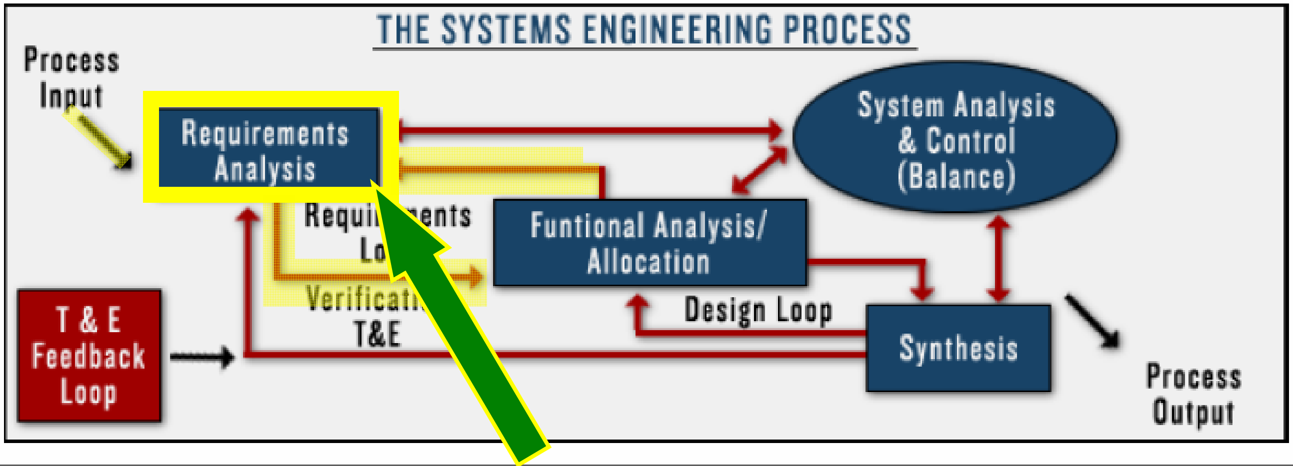
Integrated T&E

- Key component of risk management for a program
- Coordinated planning and development of individual test objectives
- Some data elements will not overlap and can only be measured in a technical, operational, or live fire environment but there can be potential for significant cost savings and earlier risk reduction
- Requires buy-in from all orgs + strong T&E WIPT



$$T\&E_{integrated} \int_{\text{Program Start}}^{\text{System Disposal}} = (\text{CT, DT, OT, LFT\&E, Joint Exp, M\&S, Analysis, etc.})\, dt$$

T&E During Sys Eng Tasks



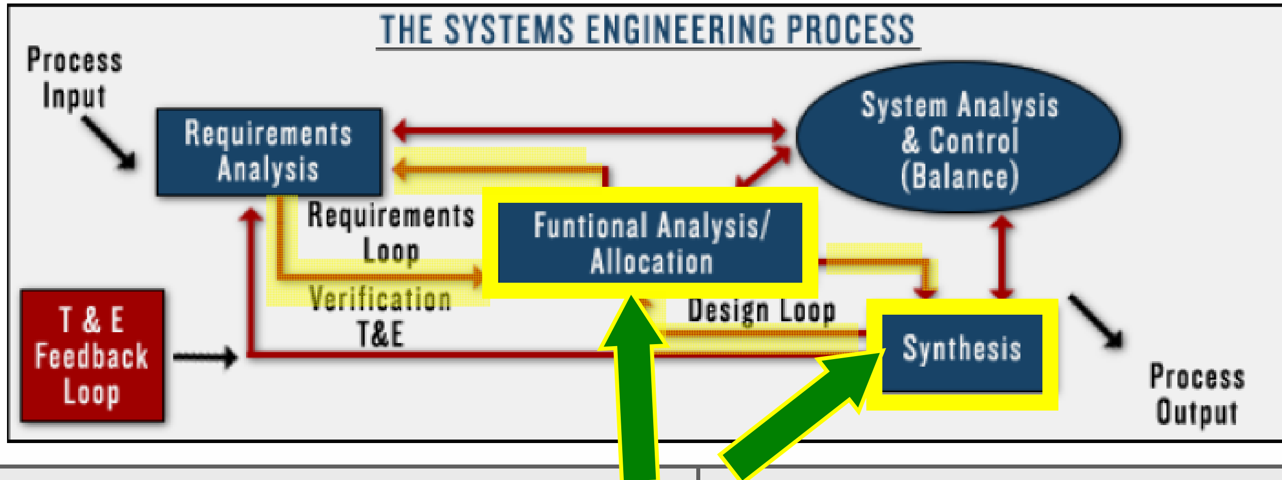
Testers support by influencing:

- Measurable, objective, meaningful reqs
- Reqs context & op scenarios
- Bounding system (technical/operational)
- Assisting mission / functional breakdown
- TPM selection
- Influencing HSI
- Prioritization of reqs (critical / need / want)
- IV&V of reqs flowdown + delivered technical and operational capabilities

T&E is supported by insight into various aspects of project to facilitate efficient test planning:

- Customer expectations
- Project & external constraints (CAIV…) Reqs context and intentions
- Life cycle support planning
- HSI planning/design
- Physical / logical architecture drivers
- Prioritization of requirements

T&E During Sys Eng Tasks (Cont')



Testers support by influencing:

- Consistency in reqs/functional flowdown based on original intentions and op context
- Influencing HSI in detailed design including user reviews of HCI & functionality
- Verification of requirements implementation through limited component level tests
- Interface definition
- Prioritization of lower level requirements
- IV&V of reqs flowdown + delivered technical and operational capabilities
- M&S planning/development

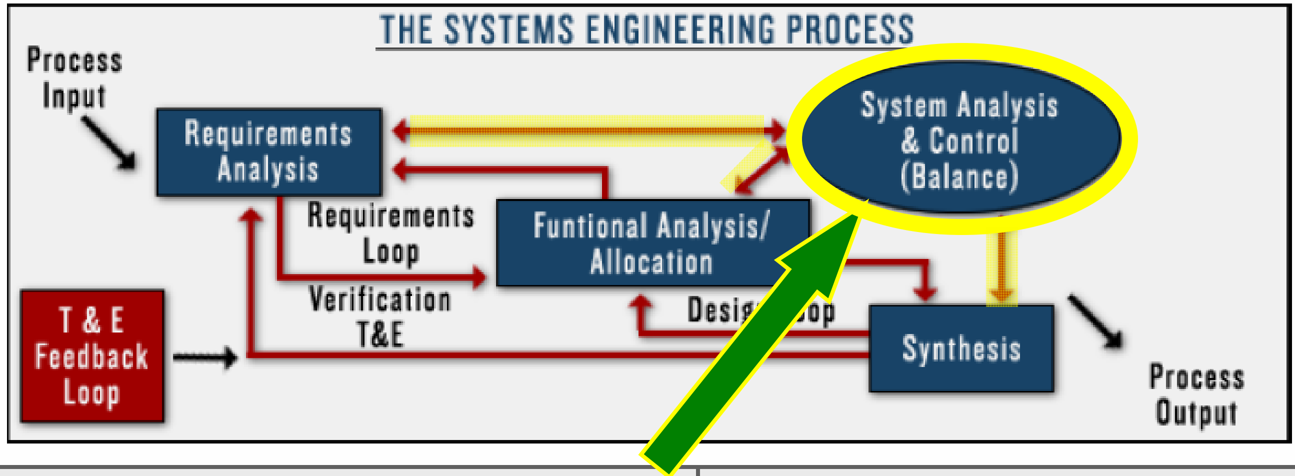
T&E supported by insight (which improves test planning efficiency) into:

- Detailed reqs flowdown and prioritization
- Detailed life cycle support planning
- HSI planning/design
- Detailed architecture drivers

& early collection of evaluation data:

- Life cycle planning
- HSI design implementation
- Software eng. process assessment
- M&S V&V
- SCI/Component & interface test data

T&E During Sys Eng Tasks (Cont')

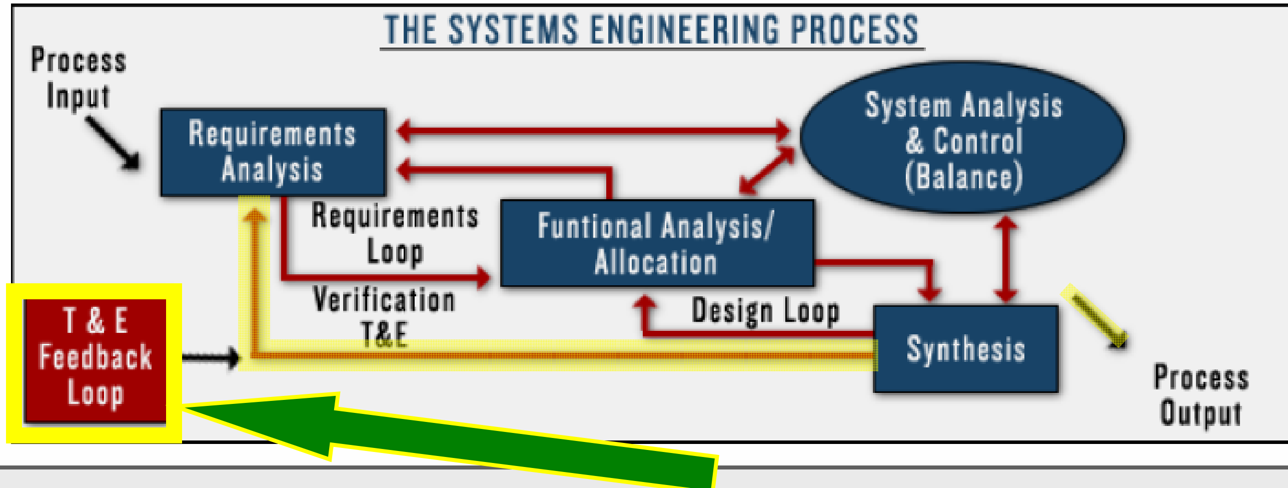


Testers support by influencing:
- M&S analysis planning
- Monitoring M&S development
- Assisting in M&S analysis execution
- Independent evaluation of analysis results
- Evaluation of systems and software engineering process/process improvement
- Independent review of risk management and input of T&E issues as new/updated risks
- Objective TPM tracking
- Design for safety, life-cycle, interoperability, & survivability (instead of merely testing)

T&E is supported by insight into:
- Capabilities and limitations from analysis that points to need for live testing
- Pre and post-test predictions
- Test design and noise factors selection (design of experiments), sensitivity studies
- System & component trade-offs

& collection of evaluation data:
- Analytical and M&S based evaluation of system performance
- M&S V&V

T&E During
Sys Eng Tasks (Cont')



Testers support by:

- Planning and executing tests to verify requirements and validate functions and mission capabilities
- Giving engineers insight into performance of system
- Independent internal and external agencies evaluation of the system

[traditional T&E – with greater participation from systems engineers & increased use of standard engineering methodology for planning efficient tests

T&E is supported by systems engineers:

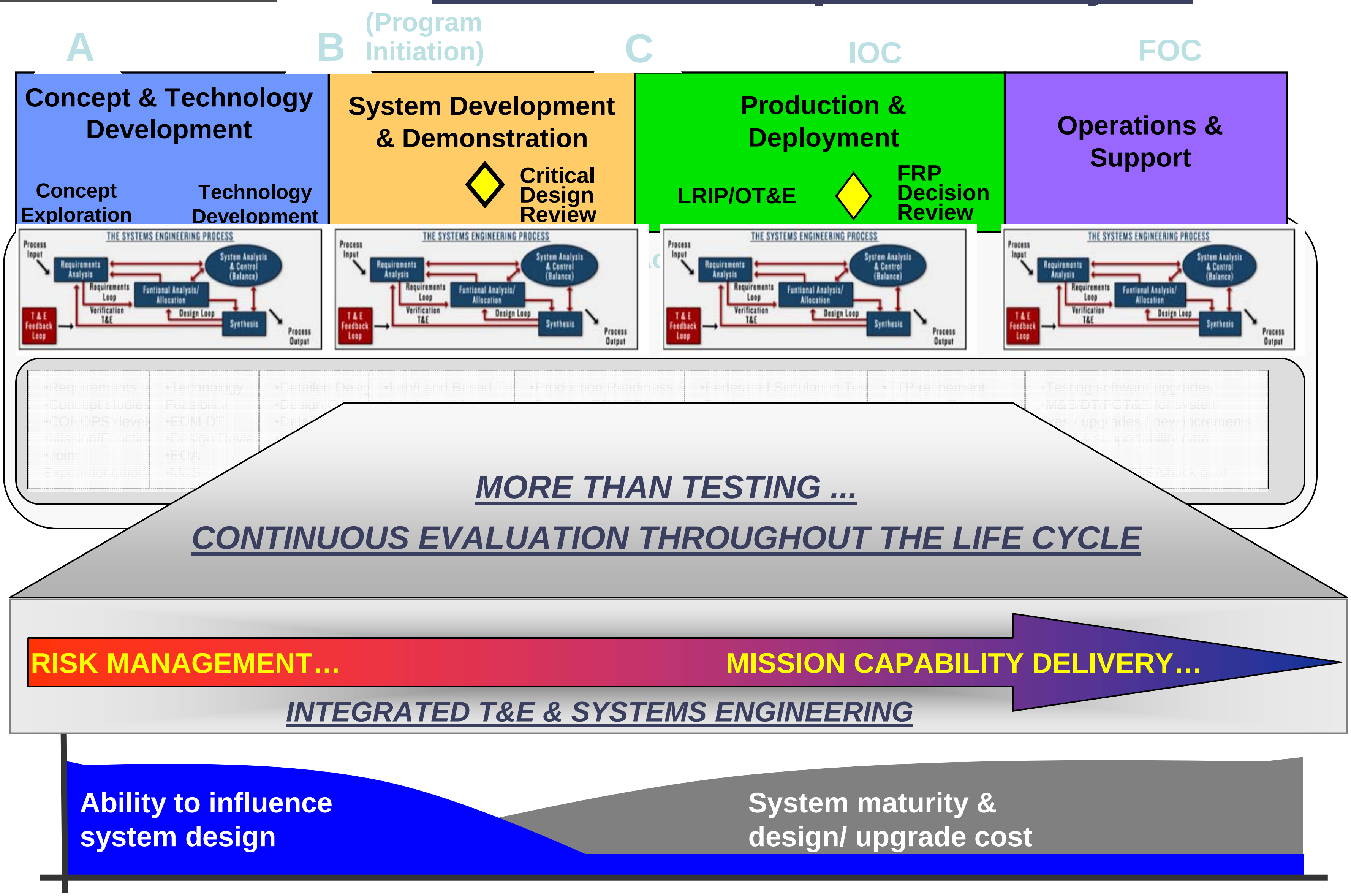
- Interpretation of technical results
- Determining impacts on HSI, life-cycle planning, IA, etc.
- Categorization of issues and problems

T&E supports accurate decision making:

- Proceeding with output to next acquisition phase, or
- Proceeding to next phase of testing, or
- Repeat of previous tasks while holding at this point in the acquisition cycle

AVW TECHNOLOGIES

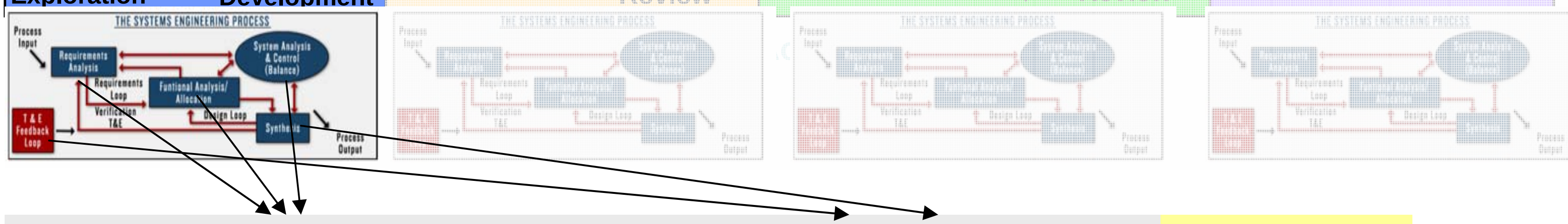
Systems Engineering + T&E within the Acquisition Cycle



Systems Engineering + T&E within the Acquisition Cycle

A — B (Program Initiation) — C — IOC — FOC

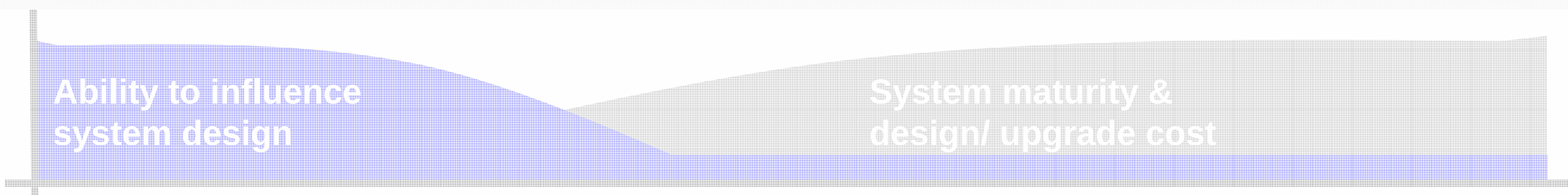
Concept & Technology Development	System Development & Demonstration	Production & Deployment	Operations & Support
Concept Exploration / Technology Development	Critical Design Review	LRIP/OT&E; FRP Decision Review	



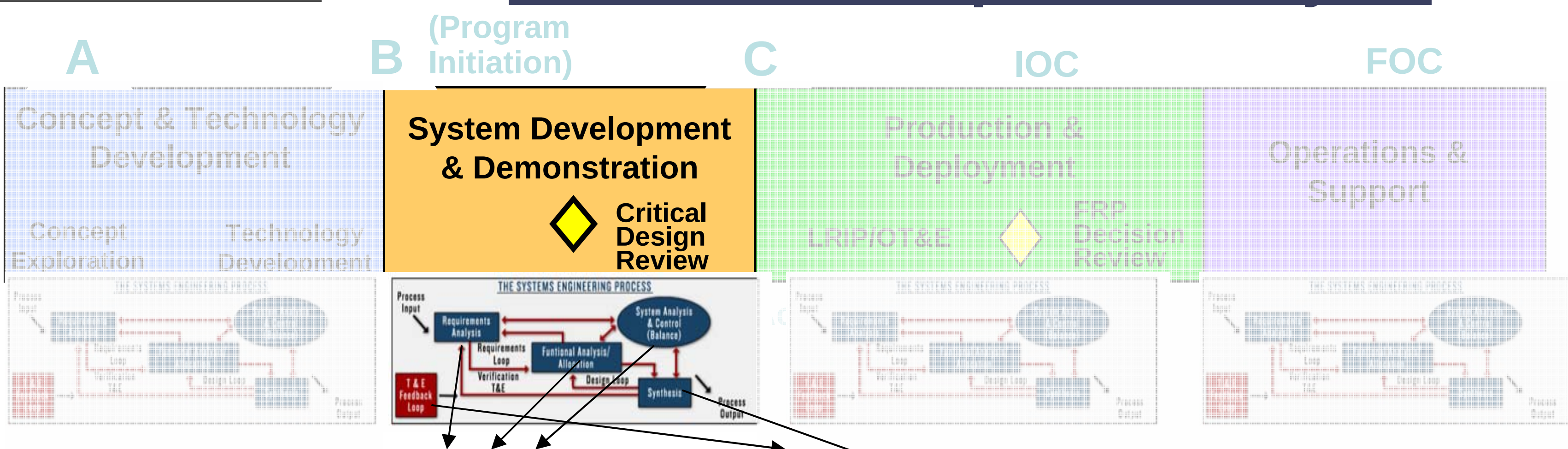
T&E ACTIVITIES DURING C&TD PHASE	•Requirements testability review •Concept studies and analysis •CONOPS development •Mission/Functional analysis •Joint Experimentation/ACTD/ATD	•Technology Feasibility •EDM DT •Design Reviews •EOA •M&S	***Testers & engineers not involved enough in this phase***

RISK MANAGEMENT… MISSION CAPABILITY DELIVERY…

INTEGRATED T&E & SYSTEMS ENGINEERING



Systems Engineering + T&E within the Acquisition Cycle

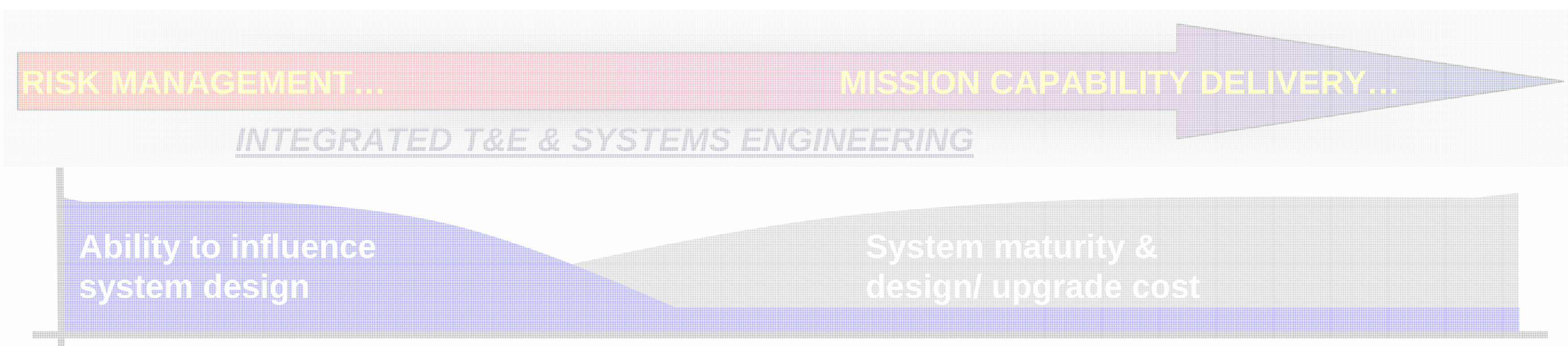


T&E ACTIVITIES DURING SDD PHASE

- •Detailed Design Rvw
- •Design OA
- •Detailed CONOPS
- •User reviews
- •TTP development
- •Trade studies

- •Lab/Land Based Testing & M&S
- •Limited field/at-sea testing & usability testing
- •Testbed/surrogate LFT&E
- •Supportability analysis/ initial logistics audit
- •RAM analysis & testing (reliability growth)
- •Certification process

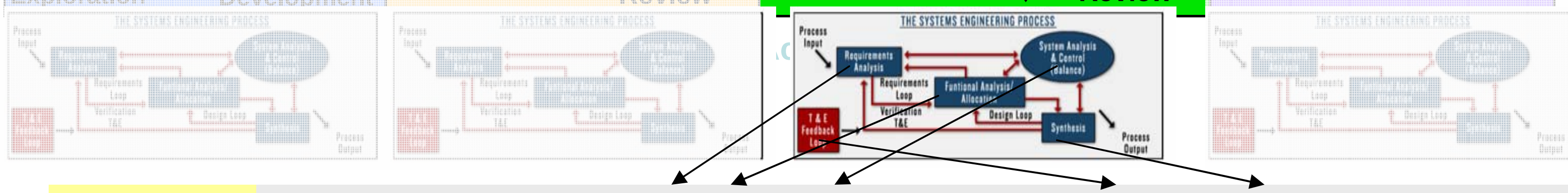
Inadequate linkage to C&TD mission and reqs analyses



Systems Engineering + T&E within the Acquisition Cycle

AVW TECHNOLOGIES

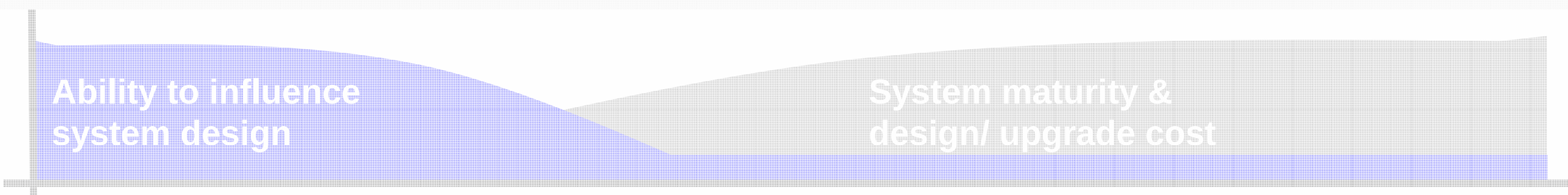
A	B (Program Initiation)	C	IOC	FOC
Concept & Technology Development	System Development & Demonstration	Production & Deployment		Operations & Support
Concept Exploration / Technology Development	Critical Design Review	LRIP/OT&E — FRP Decision Review		



Need to push as much of this to the left as possible	**T&E ACTIVITIES DURING P&D PHASE**	•Production Readiness Reviews •Detailed CONOPS •Production H/W, S/W review •Detailed TTP review/refinement •Production in-process review w/ users & verification team	•Federated Simulation Testbed •Production acceptance + mission validation DT/TECHEVAL and IOT&E •HSI, Manpower, Personnel, Trng Eval •System LFT&E & Shock Qual •Final Independent Logistics Audit

RISK MANAGEMENT… MISSION CAPABILITY DELIVERY…

INTEGRATED T&E & SYSTEMS ENGINEERING



Systems Engineering + T&E within the Acquisition Cycle

AVW TECHNOLOGIES

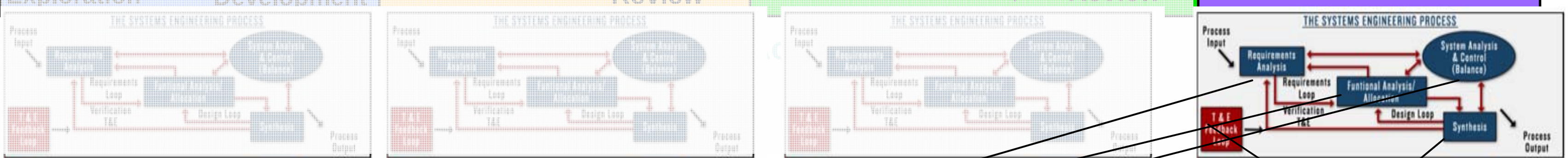
A | B (Program Initiation) | C | IOC | FOC

Concept & Technology Development — Concept Exploration; Technology Development

System Development & Demonstration — Critical Design Review

Production & Deployment — LRIP/OT&E; FRP Decision Review

Operations & Support



Upgrades/ increments need better tie to req capability & tech maturity

T&E ACTIVITIES DURING O&S PHASE

- •TTP refinement
- •Software/System problem characterization & tracking
- •Upgrade/ P3I / spiral development requirements analysis
- •Testing software upgrades
- •M&S/DT/FOT&E for system fixes / upgrades / new increments
- •RAM & supportability data collection
- •Additional LFT&E/shock qual

RISK MANAGEMENT… MISSION CAPABILITY DELIVERY…

INTEGRATED T&E & SYSTEMS ENGINEERING

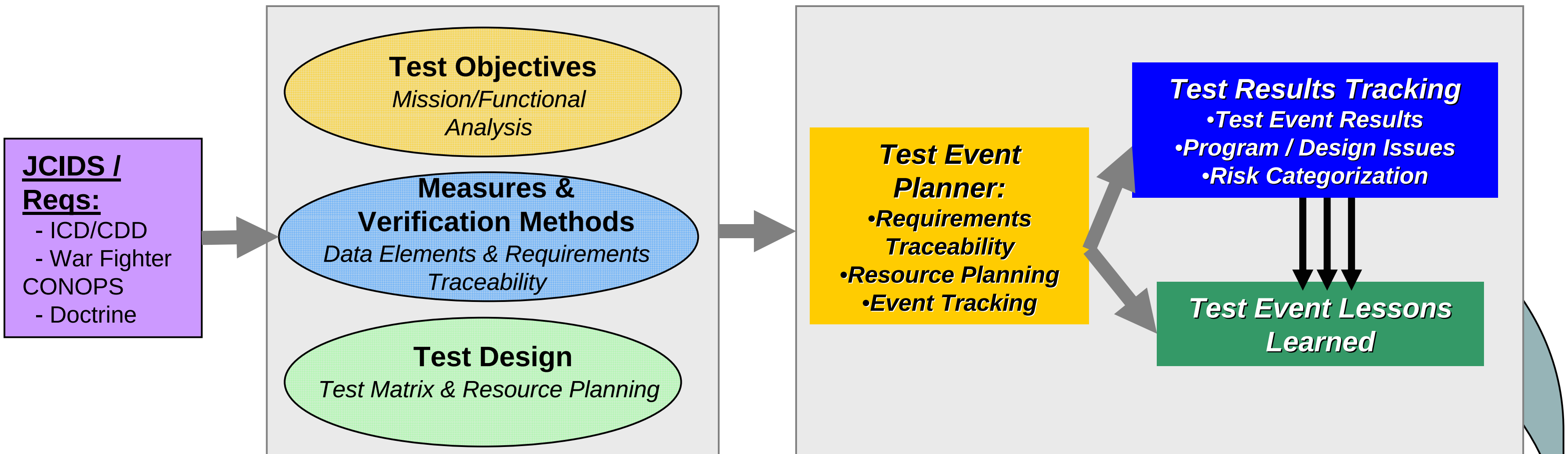
Ability to influence system design

System maturity & design/ upgrade cost

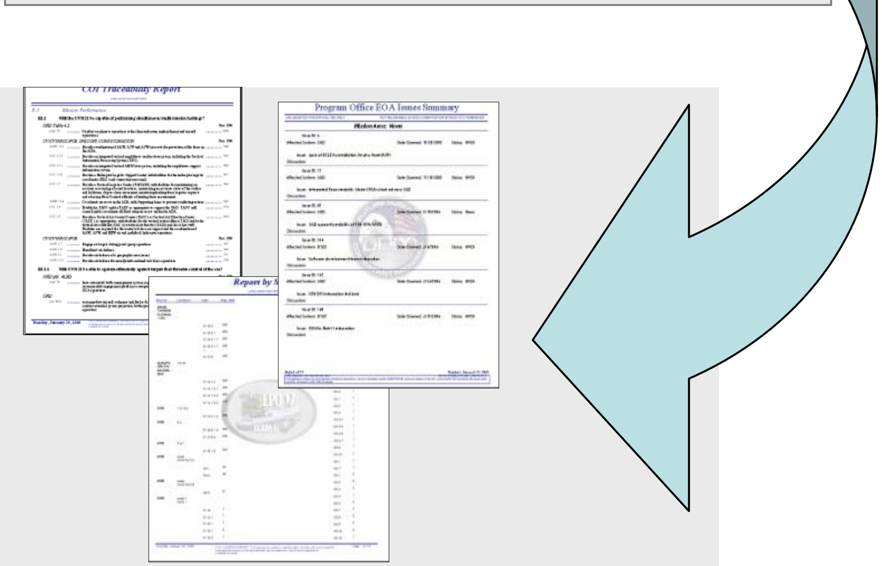
Enablers for implementing IT&E for risk-management

- Actually implementing a process for IT&E with adequate buy-in is the first step
- Use software tools to step through planning and reporting processes and document IT&E
- Implement risk based test planning and reporting
- Other recommendations to follow…

T&E Framework Toolset

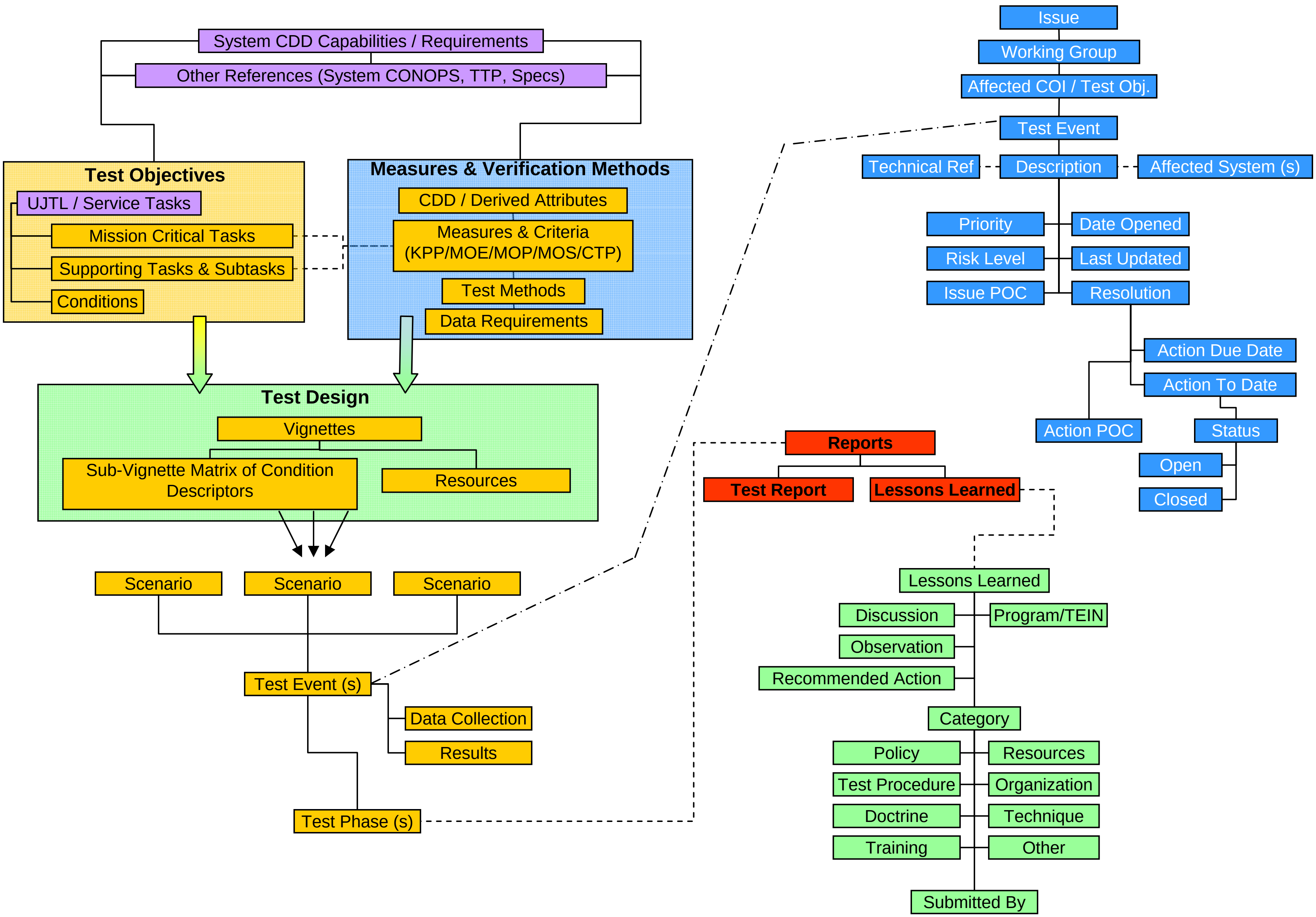


- •TEMP Inputs
- •Test Plan Inputs
- •Test Report Inputs (Results and Issues)
- •Tailored Reports for Issue Status to User



AVW TECHNOLOGIES

T&E Framework Toolset Architecture

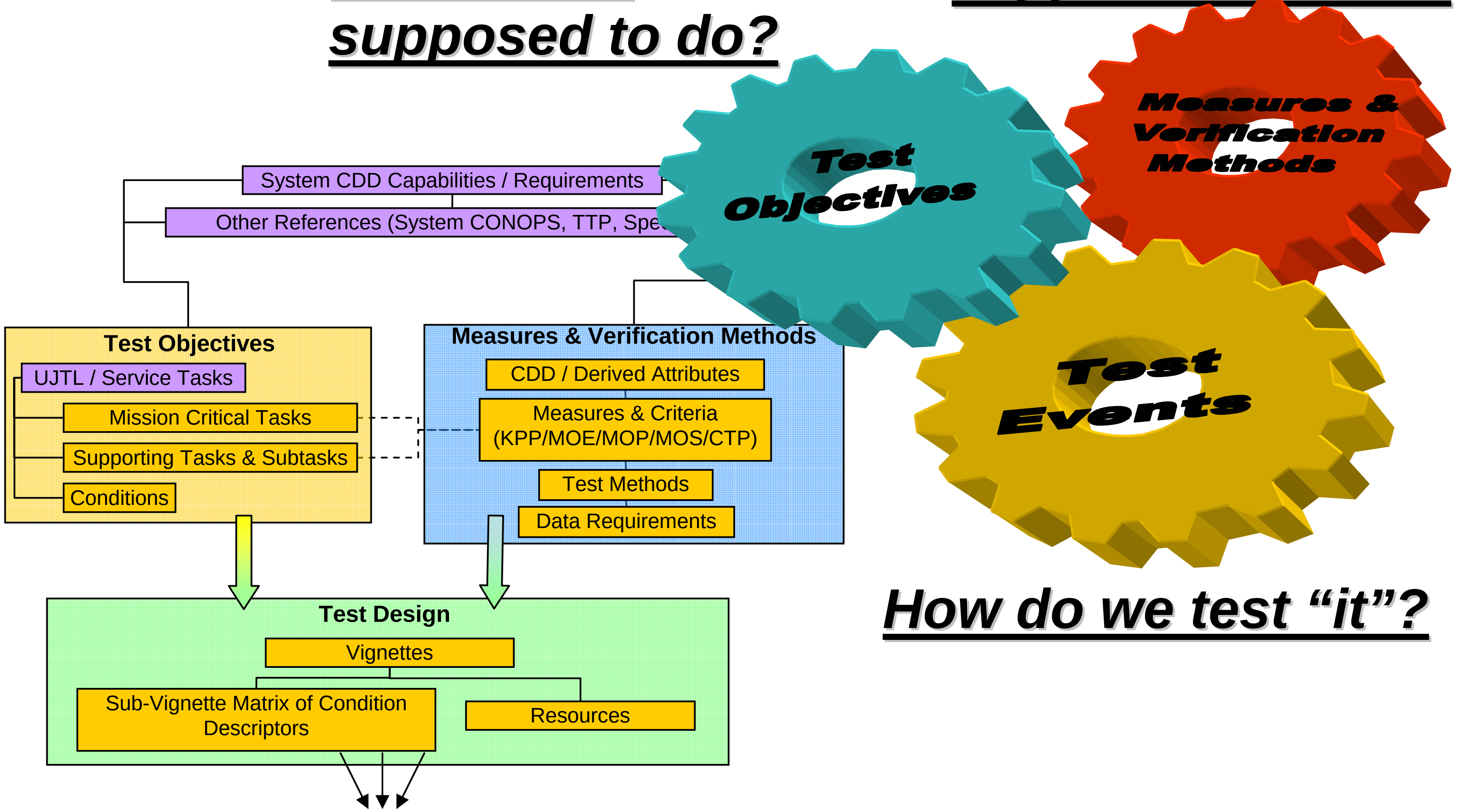


T&E Framework Toolset

Mission Based Test Design

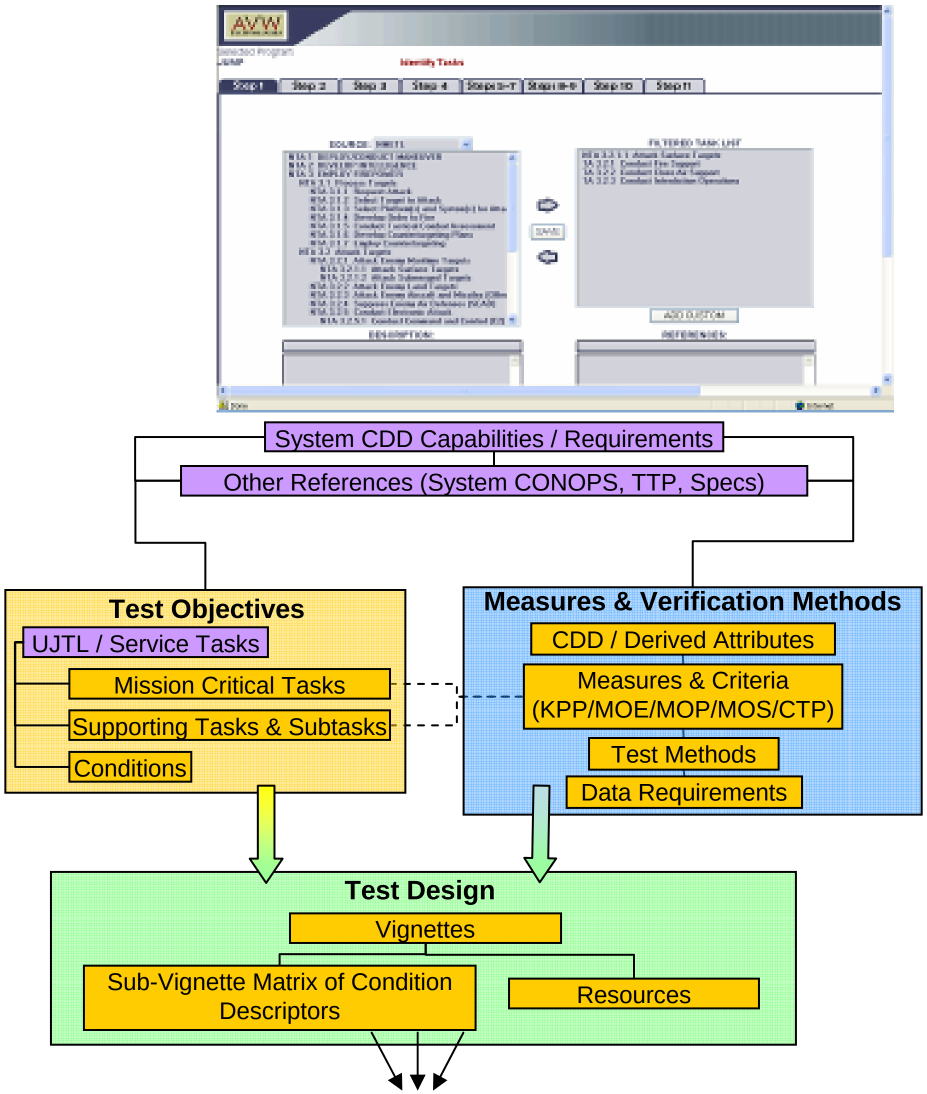
How well is "it" supposed to do it?

What is "it" supposed to do?



How do we test "it"?

T&E Framework Toolset Functions / Capabilities

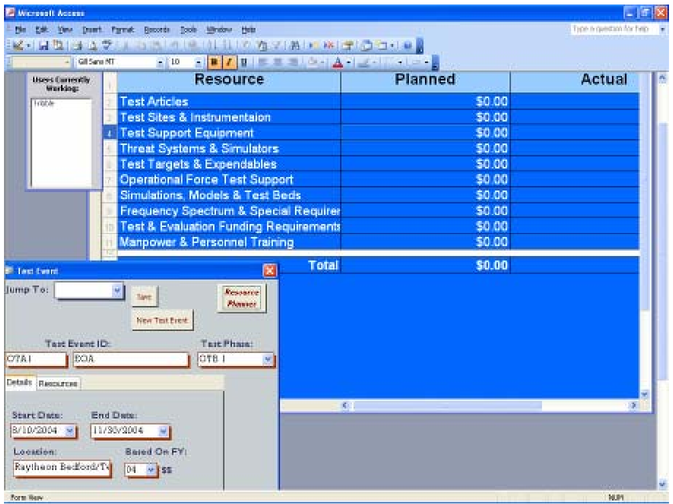


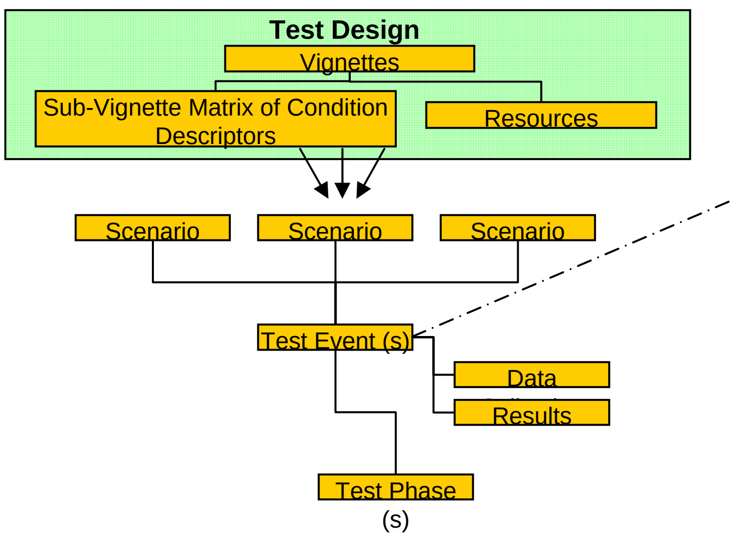
- Review of requirements, capabilities, mission tasks, or functional tasks
- Development of COIs/ Test Objectives

- Develop MOE/MOS/MOP/CTP and trace to test objectives and source requirements
- Develop test method and data requirements for each measure

- Group test objective/tasks into testable blocks (vignettes) and determine resources
- Develop test matrix based on conditions

T&E Framework Toolset Functions/Capabilities (cont')





•Identification of test objectives and measures for a given event (exported from T&E Framework Tool)

•Resource and cost estimation to support TEMP, budget programming, test planning, and other efforts including ties for each resource to test objectives.

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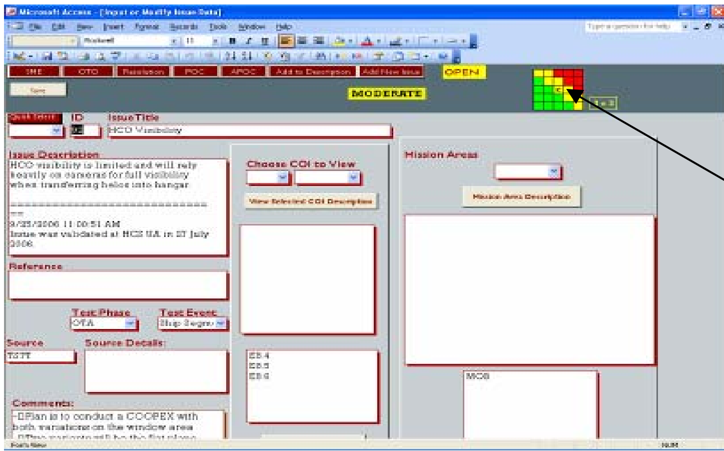
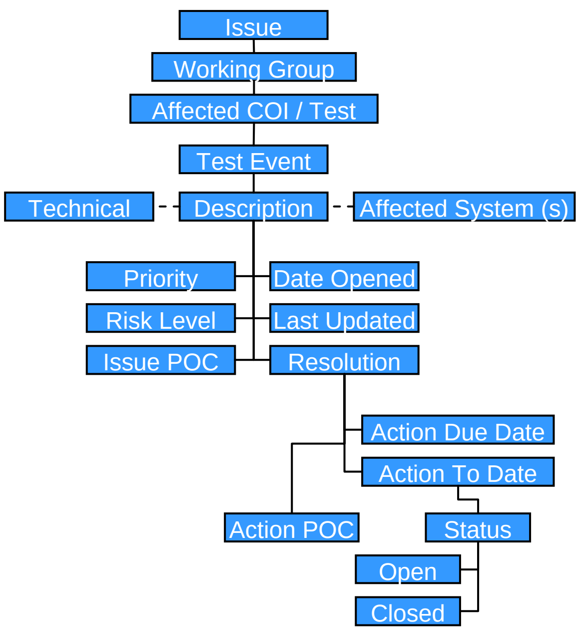
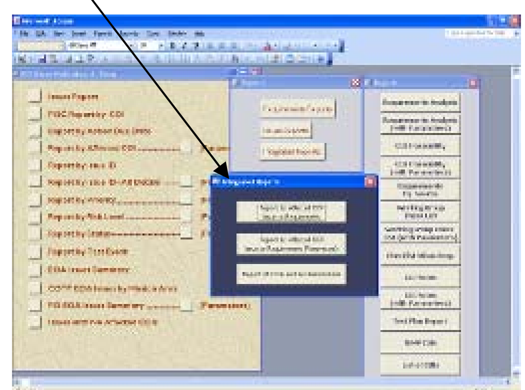
T&E Framework Toolset Functions/Capabilities (cont')

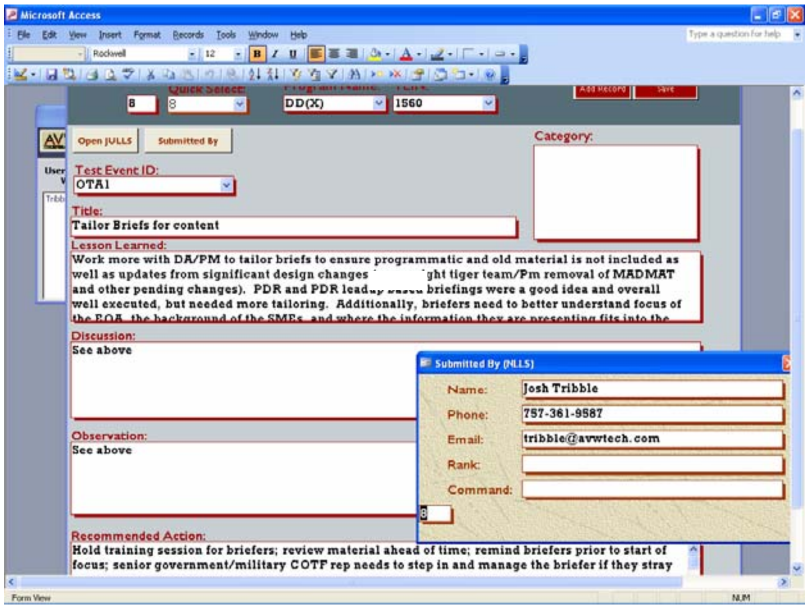


- Traceability of test results to test event to objectives to parent requirements
- Risk based issue assessment
- Rapid reporting of issues
- Long term archiving of test results and program status
- User tailored reports to assess risks by function, mission area, system, req., etc.

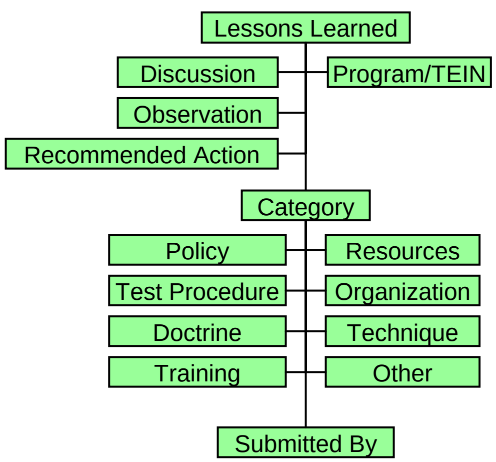




T&E Framework Toolset Functions/Capabilities (cont')



- Lessons learned tracking in standard Joint/Service Lessons Learned formats
- Cross program visibility for T&E process maturation and cost reduction identification



Risk Based Test *Planning & Resourcing*

Probability of Occurrence / Consequence	5	4	3	2	1
A – Frequently occurs during tests/operations (prob ~ 1.0)	II	II	I	I	I
B – Probably will occur during tests/operations	III	II	II	I	I
C – Occasionally may occur during tests/operations (prob ~ 0.5)	III	III	II	II	I
D – Remote chance to occur during tests/operations	III	III	III	II	II
E – Not likely to occur during tests/operations (prob ~ 0)	III	III	III	III	II

Consequence Levels:

1: prevents accomplishment of primary mission or presents a serious safety hazard

2: sig pri mission degradation w/o a work-around, secondary mission failure, or mod safety hazard

3: major secondary mission degradation w/o work-around; pri mission degradation w/ work-around

4: minor degradation/impact to primary and secondary missions

5: no impact to mission but operator annoyance or recommended enhancement

Risk Levels:

I: High Risk – The spec/req/capability req significant CT, some independent DT and OT; highest pri for resource allocation; more test runs/ conditions permutations than other tests; most scrutiny required before integrating tests

II: Moderate Risk – Requires some dedicated DT and OT; medium resource priority; less scrutiny before integrated tests completely

III: Low/Manageable Risk – Little to no independence between CT, DT, OT, and LFT&E req; strong candidate for fully leveraging a small set of integrated tests for all data; lowest priority for resource allocation.

This supports TEMP test event and resource allocation + detailed test planning; removes much of subjectivity surrounding allocation of scarce testing funding.

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Risk Based Test *Reporting*

Probability of Occurrence Consequence	5	4	3	2	1
A – Frequently occurs during tests/operations (prob ~ 1.0)	II	II	I	I	I
B – Probably will occur during tests/operations	III	II	II	I	I
C – Occasionally may occur during tests/operations (prob ~ 0.5)	III	III	II	II	I
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Consequence Levels:
1: prevents accomplishment of primary mission or presents a serious safety hazard
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3: major secondary mission degradation w/o work-around; pri mission degradation w/ work-around
4: minor degradation/impact to primary and secondary missions
5: no impact to mission but operator annoyance or recommended enhancement

Risk Levels:

I: High Risk – resolve prior to fielding & conduct major re-test of mission area prior to fielding with the most resources applied

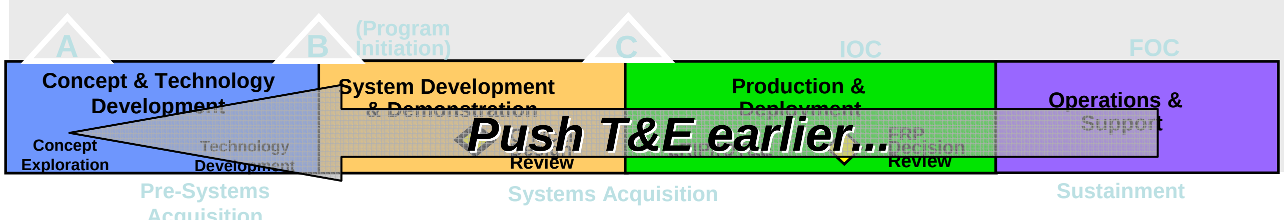
II: Moderate Risk – resolve prior to fielding and re-test the specific requirement as soon as possible (depending on the requirement, re-test may be allowed to be conducted during follow-on T&E after fielding); apply moderate amount of resources to re-test

III: Low/Manageable Risk – resolve when possible but does not impact fielding; re-test at next available previously planned test event; lowest prioritization for test resources

This could be tied directly to risk register and supports reporting of CT, DT, OT, LFT&E, M&S Runs, or any other analysis or test

Additional Recommendations

- Fully implement IT&E top-down and institutionalize with PEO/PM orgs
- closer align T&E Strategy/TEMP, Systems Engineering Management Plan, and Acquisition Strategy
- Maximize test data and usage of that data across test programs and fully align results to the program's risk registry
- Conduct assessment and testing as early as possible and with all organizations to support risk mitigation
- More test objective to requirements traceability in the TEMP
- Service T&E reorganize to Enterprise business model to drive IT&E plus alignment with JT&E, DOT&E

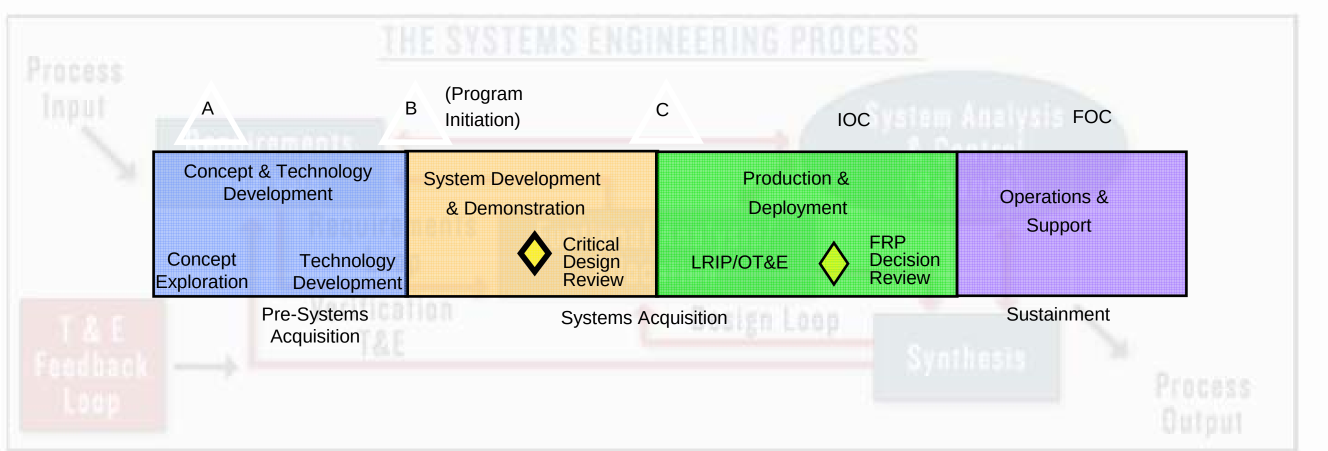


Additional Recommendations (cont')

- Implement more systems engineering rigor across T&E
- Collect metrics on early risk mitigation efforts of T&E
- Develop and field in consolidated baselines to reduce testing, integrate across programs not just within
- Stress to threats and operating environments early and often
- Change T&E score-card to a risk assessment vs. capabilities; continuous feedback throughout tests; foster more cooperation including leveraging JT&E, Experimentation, Training Exercises
- Increase PM focus on life cycle, HSI, other factors beyond technical mission performance
- Coordinate use of standard statistical methodology for T&E including Design of Experiments

(Note—similar presentations made to '05 & '06 NDIA Sys Eng Conferences)

Conclusion



Questions?

Backups

Author Bio

- Former Naval officer
  - Active Duty: Surface Warfare Officer
    - Tomahawk, Aegis warfare experience + HM&E
    - COMOPTEVFOR Operational Test Director for land attack warfare systems
  - Reserve: OIC of Navy Reserve Embarked Security Det
- Current AVW experience
  - LPD-17 air defense (P_{RA}) M&S management
  - Amphibious ship combat systems T&E
  - Joint Maritime Assault Connector JCIDS analysis
  - Current project: DD(X) OT&E support focusing on IOT&E planning, OA execution, M&S, and total ship test management

<u>10 years operational & 6 years acquisition experience focusing on T&E and systems engineering</u>

AVW TECHNOLOGIES

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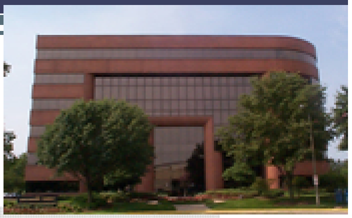
AVW TECHNOLOGIES

Company Profile



Professional Engineering Services

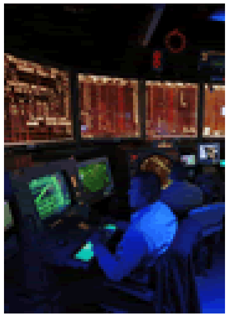
ORD, ICD, CDD, TEMP, Systems Engineering, Systems Integration, M&S Management

Test and Evaluation Support

TEMP, DT/OT, Test Management, Test Plans, Execution, Data Collection, Analysis

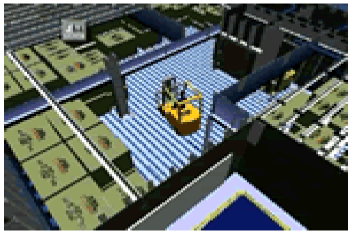
Shipbuilder Engineering Management Consulting

Systems Engineering, Systems Integration, M&S Management



Contract Vehicles:

Obtained GSA PES schedule CY04
NAVSEA MAC member thru JJMA and CSC
NAVSEA Seaport-E



Corporate Highlights:

Total Ship / System of Systems Focus
Expeditionary Warfare Expertise
Mission Focused Systems Engineering and Analysis
Matrix support leverage full corporate capabilities
37 military analysts and IT/admin support
Small veteran owned business since 2002
Headquarters in Chesapeake, VA

INNOVATIVE SOLUTIONS TO THE CHALLENGES OF THE FUTURE

23rd Annual NDIA T&E Conference

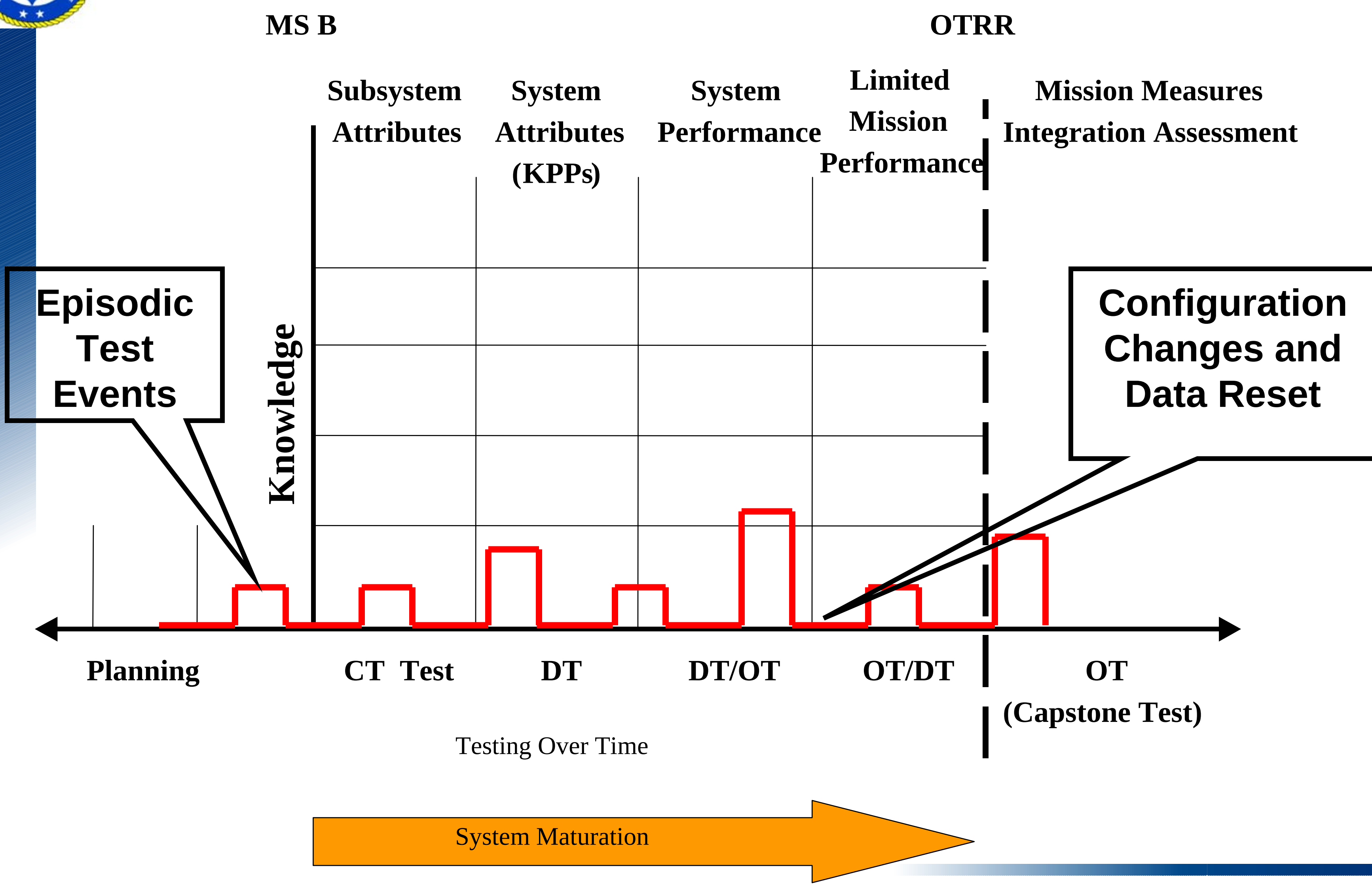
"Test and Evaluation in Support of Operational Suitability, Effectiveness and Sustainment of Deployed Systems"

Steven Whitehead
Technical Director
Navy Operational Test and Evaluation Force
15 March 2007

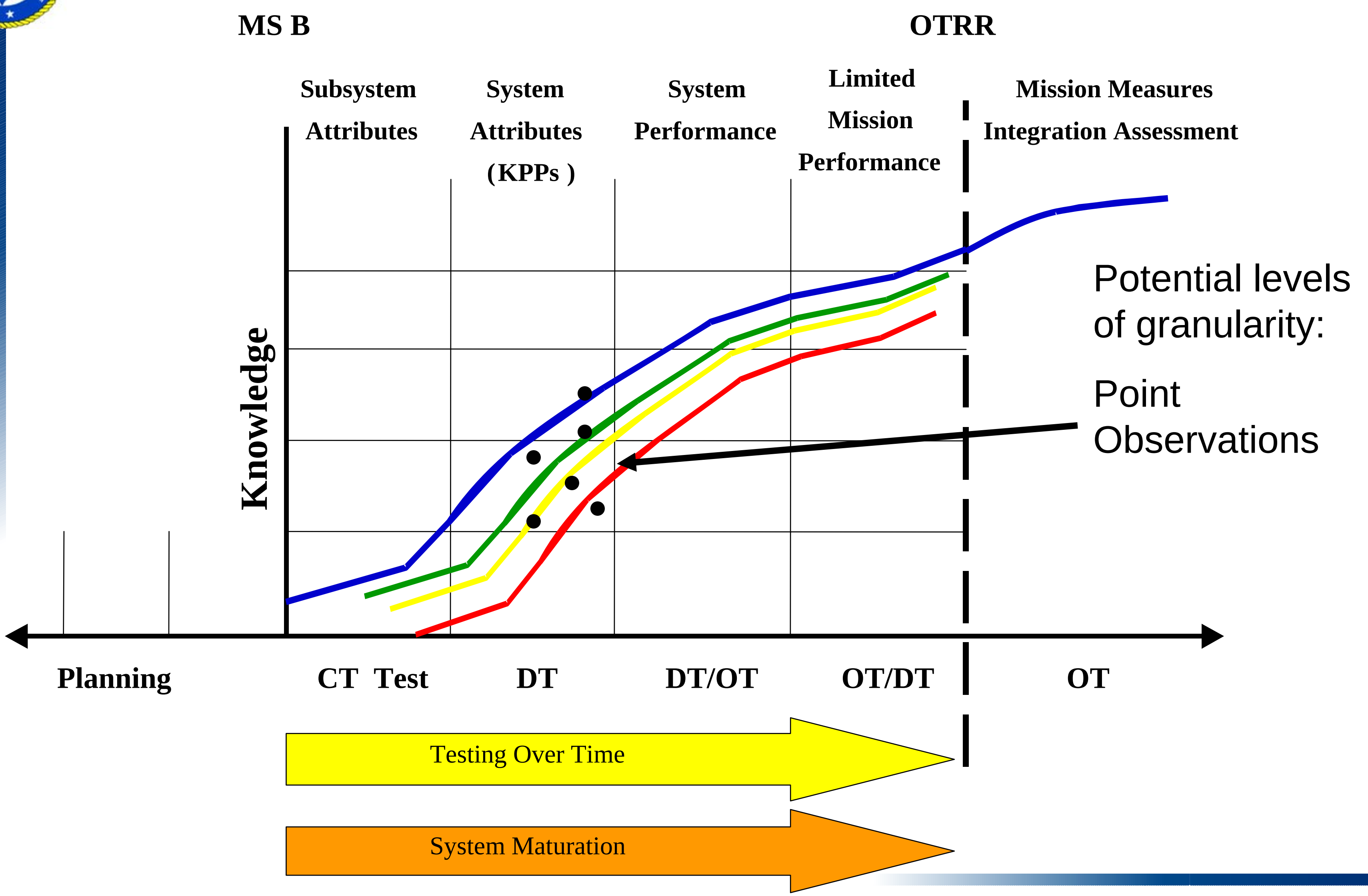
T&E Rapid Response to the Warfighter

- How does the T&E community, as part of the systems engineering process:
  - Obtain, maintain, and increase its body of knowledge, to assess and project with greater confidence, a product's potential capability and suitability (A_o, Reliability, Deployability, Sustainability) during product development as the product and requirements change?
- Knowledge not limited to quantitative data

“Traditional” T&E Process



Integrated Test
Knowledge Over Time



Several Benefits to Dynamic System T&E

- Greater depth and breadth of knowledge
- Greater understanding of impact to changes
- Greater understanding of test cost
- Greater ability to assess product capability at points in time.

Several Challenges to Dynamic System T&E

- Transparency – ability to see across boundaries
- Permeable boundaries – ability to pass information and data (transportability) across boundaries
- Product configuration management
- Graduated Reliability during development
  - Thresholds (maturity measures)

The Four-Element Framework: An Integrated Test and Evaluation Strategy

Christopher Wilcox

Army Evaluation Center
Aviation Evaluation Directorate
Aberdeen Proving Ground, MD
13 March 2007

Our Army . . .Our Soldiers . . .Our Equipment

Agenda

- Background
- Introduction
- Overview
- Element/Interface Development
- Application
- Weaknesses/Strengths
- Conclusions

Background

DoD 5000.1

DOD 5000.1 – "The primary objective of Defense acquisition is to acquire quality products that **satisfy user needs with measurable improvements to mission capability**…"

JCIDS

Joint Capabilities Integration and Development System

- War Fighting Capability Gaps
- Material/Non-material Solutions

Materiel System
Performance Attributes
Key Performance Parameters

Capabilities Development Document

Capabilities Production Document

OV Operational View – mission tasks, activities, operational elements and information required to accomplish warfighting mission.

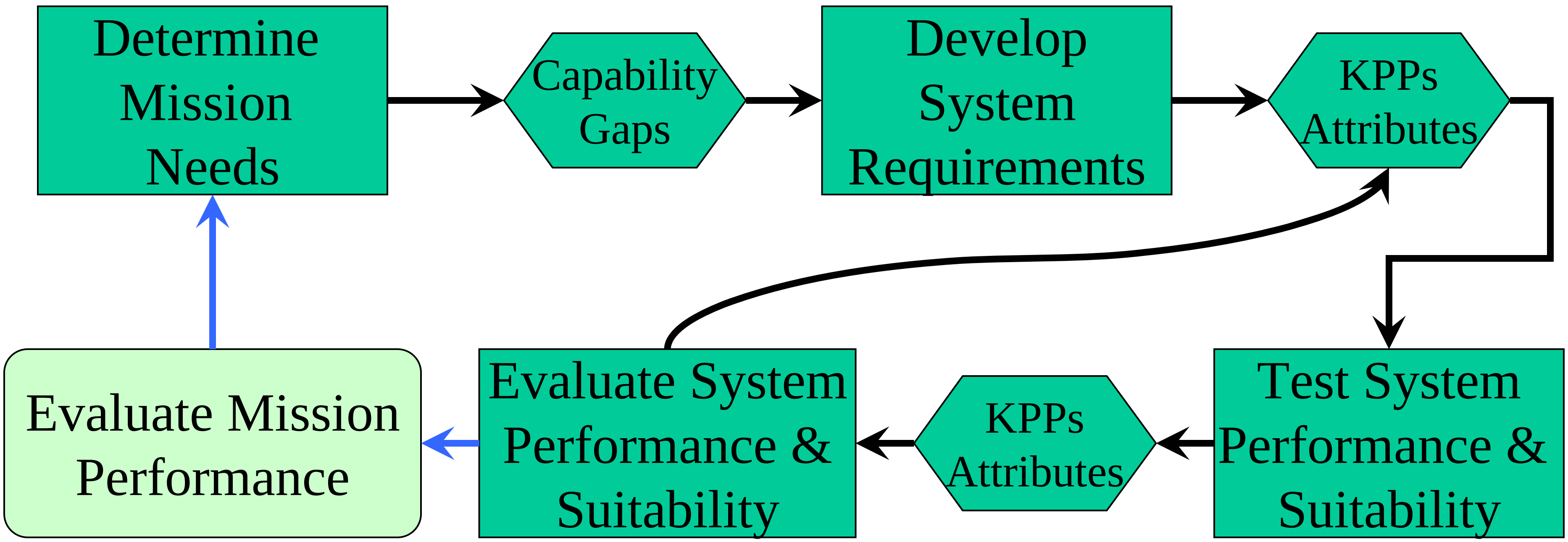
SV System View – system elements and capabilities necessary to support warfighting functions.

TV Technical View – set of rules and standards to ensure that a system satisfies a set of operational requirements.

AV All View – overarching architecture that supports the OV, SV and TV.

Introduction

T&E Process Paradigms: Traditional; Proposed



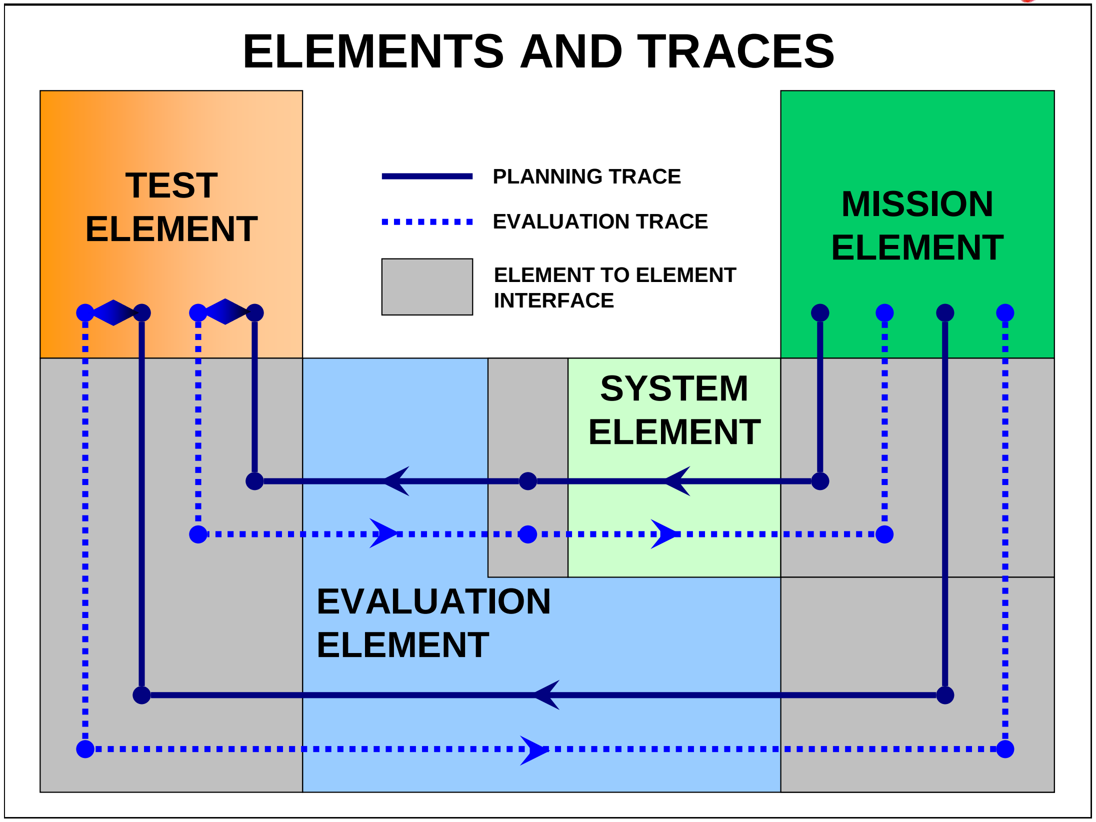
Completes the Feedback Loop to Mission Needs

Overview

The Four Elements

Mission Perspective		T&E Perspective
Purpose (What)	**MISSION ELEMENT** Mission Tasks and Sub-tasks	Purpose (What)
Means (How)	**SYSTEM ELEMENT** System and Sub-system Functions	
	EVALUATION ELEMENT Mission Ability and System Capability Measures	Means (How)
	TEST ELEMENT Data Products and Data Sources	

Overview
Elements, Interfaces and Traces



<u>Elements</u>

- Mission, System, Evaluation, and Test

<u>Interfaces</u>

- Mission to System
- Mission to Evaluation
- System to Evaluation
- Evaluation to Test

<u>Traces</u>

Planning = Mission to Test

Evaluation = Test to Mission

Two Types:

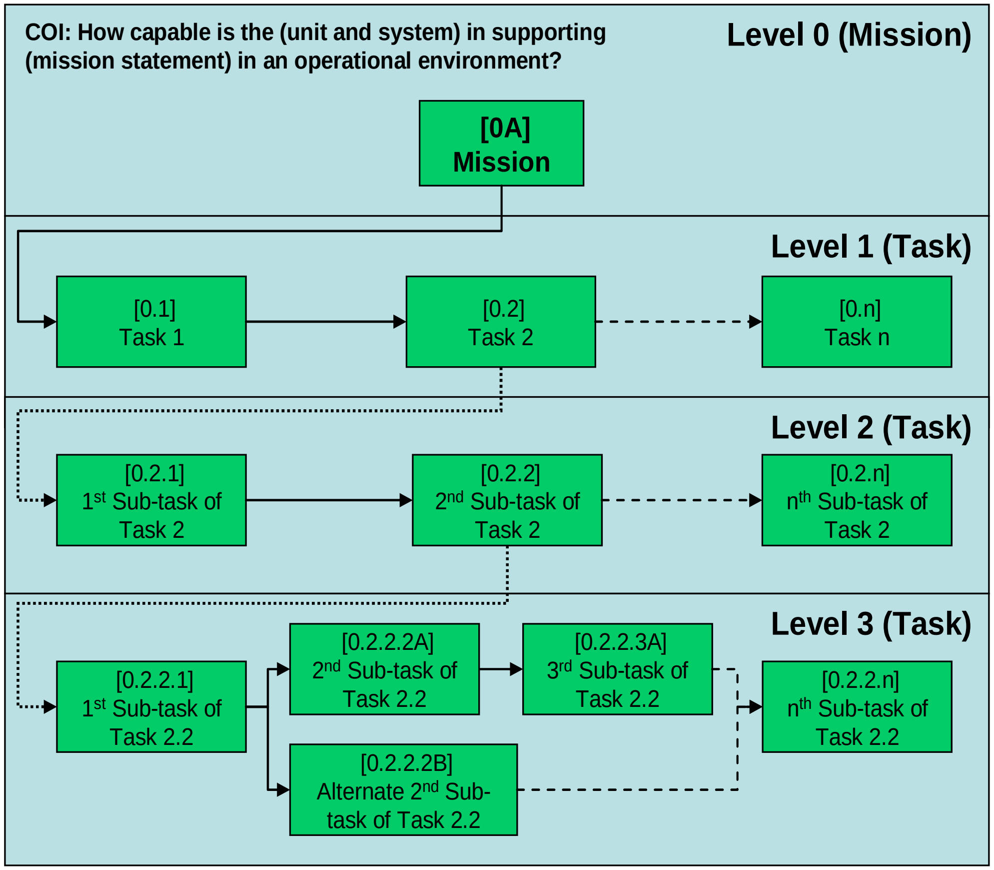
- Type 1 links Mission, System, Evaluation and Test Elements.
  - Plans and evaluates mission task ability through system function capability.
- Type 2 links Mission, Evaluation and Test Elements.
  - Plans and evaluates mission task ability directly.

Element/Interface Development Mission Element

Purpose

- To describe unit mission and tasks.

-- A task is defined as a discrete action that the unit (system and its operators) must perform in order to accomplish its mission.



Components

- Critical Operational Objective: Mission based – "How capable is the (unit and system) in supporting (mission statement) in an operational environment."

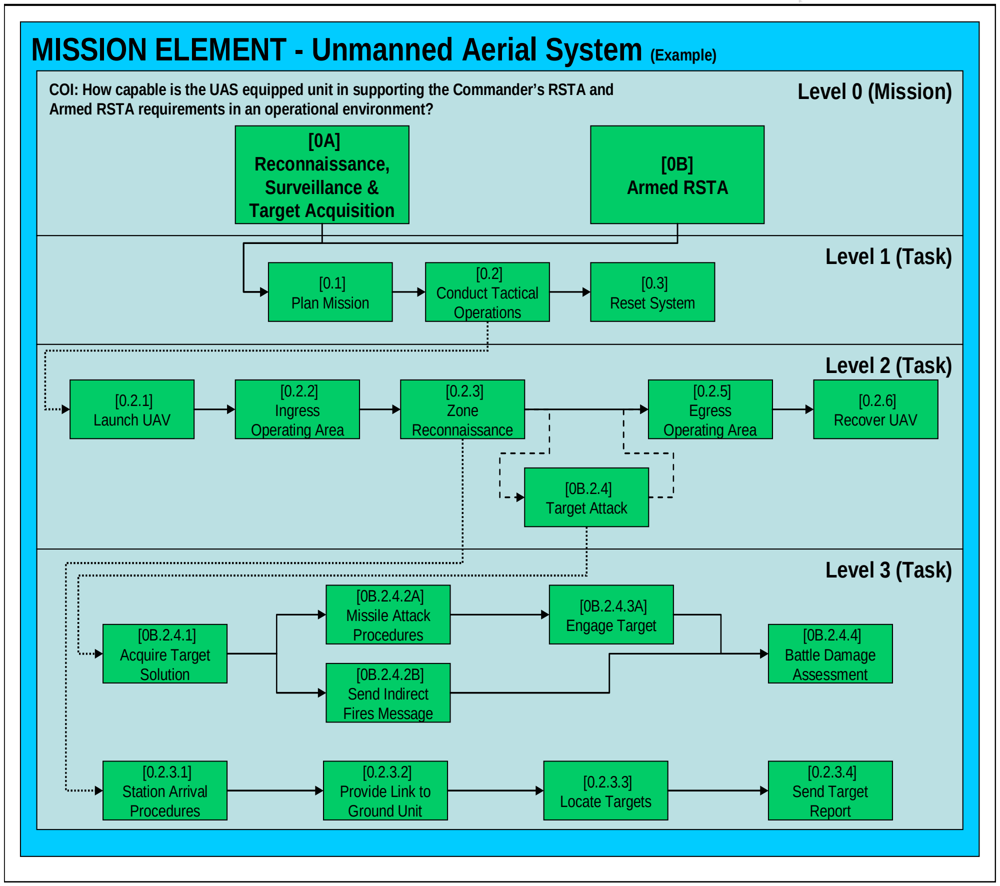
- Task Levels: Orderly breakdown of the mission into tasks and sub-tasks.

- Alternate Mission Tasks: Optional mission tasks used to accomplish part(s) of the mission. Alternate task options define different "mission threads."

Element/Interface Development Mission Element – Example

<u>Development Keys</u>

- Temporal Format.
  - Temporal format provides a block diagram of mission to mission tasks in order of their occurrence.
  - Supports development of mission threads.
- Lowest Level of Mission Tasks.
  - Lowest level mission tasks must be measurable.
  - Evaluated directly or indirectly via evaluation of system function capability.
- Support Documents.
  - Mission Need Statement, Initial Capabilities Document, Operational and Organizational Plan, Universal Task Lists, Capabilities Development/Production Documents (CDD/CPD).
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - OV-1: Who, How, Where, When, Why of the system and its mission.
    - OV-5: Operational activities (mission tasks).
    - OV-6c: Association of capabilities with sequences of operational activities (mission tasks).



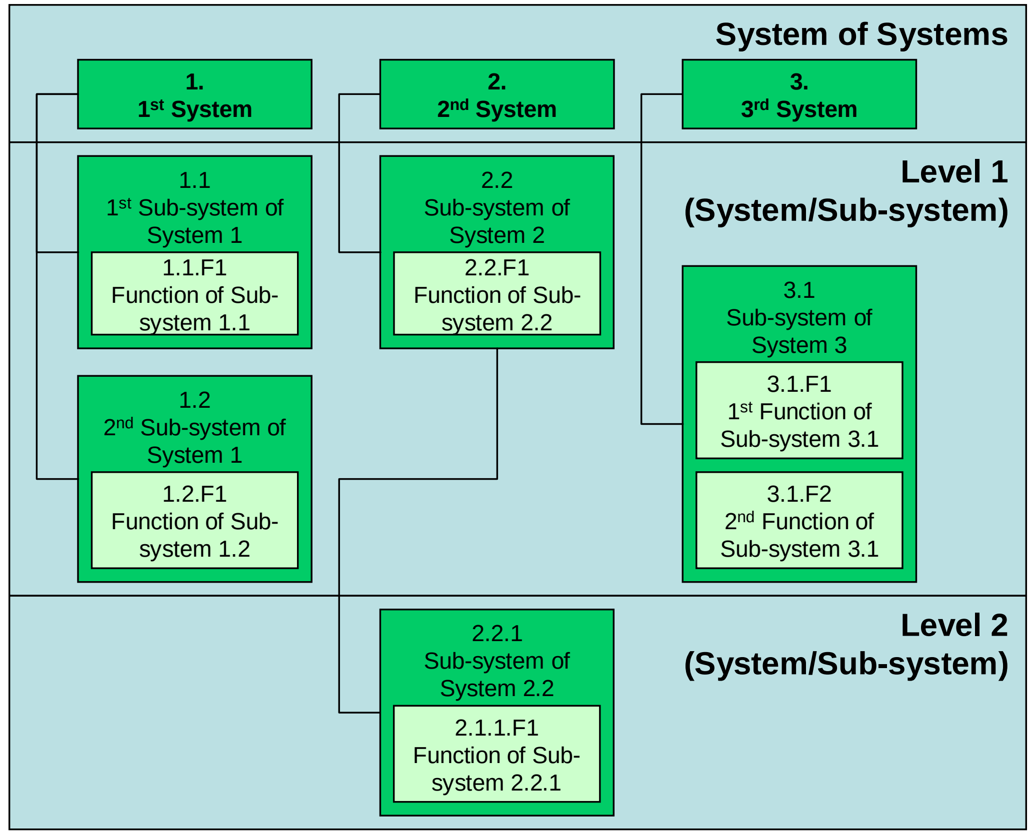
Element/Interface Development System Element

Purpose

- To describe the system and the system functions.

Components

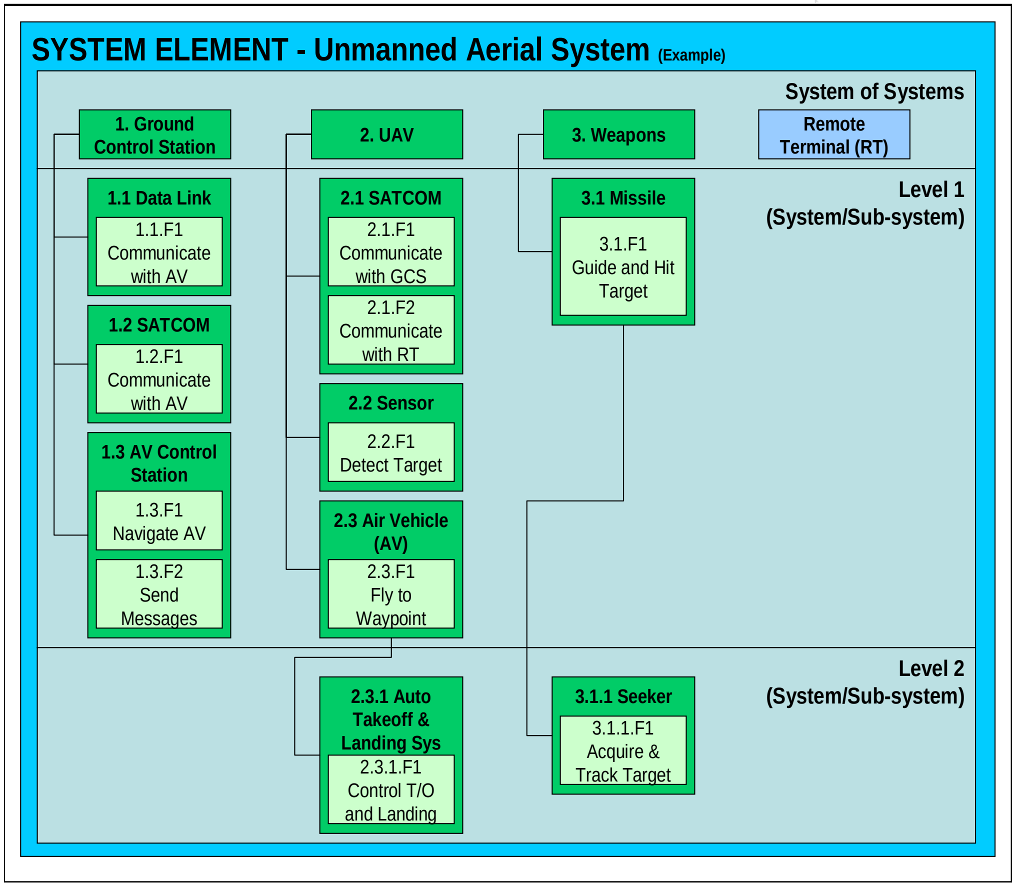
- System Items: Makeup of the system and sub-systems.
- System Functions: Description of the function an item must perform in support of the mission.
- System Level: Level of systems, sub-system, and components from the system-of-systems perspective.



Element/Interface Development System Element – Example

Development Keys

- Item to Function Link.
  - Objective is to define the system functions.
  - System item is the sub-system responsible for providing the function.
- System-of-Systems.
  - Include systems that are not part of the system being developed and evaluated if they are required to support the mission.
- Lowest Level of System Function.
  - Should be associated with the accomplishment of a mission task.
  - Measurable by T&E.
- Risk Areas
  - Items and functions can be based on a specific area of developmental risk.
- Support Documents.
  - System Work Breakdown Structure
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - SV-1: Systems required to support the mission and the interfaces between them.
    - SV-4: System functions required to support the operational activities (mission tasks).



Element/Interface Development
Mission to System Interface

<u>Purpose</u>

- To describe how the mission tasks relate to the system functions.

<u>Components</u>

- Mission Tasks: Taken from the mission element.
- System and System Functions: Taken from the system element.
- Input Rule: Description of how the system and its functions relate to the mission task. Uses logical input rules, such as AND and OR to describe links to more than one system or function.
- Conditions: Description of the physical, military, and civil variations that effect performance of a task. For example; weather conditions, countermeasures, urban environment, etc.

	[0.1] Task 1	[0.2.1] 1st Sub-task of Task 2	[0.2.2.1] 1st Sub-task of Task 2.2	[0.n] Task n
System 1	Input Rule (AND/OR)	Input Rule (AND/OR)	Input Rule (AND/OR)	
1.1.F1 Function of Sub-system 1.1	Input Rule (AND/OR) Conditions		Input Rule (AND/OR) Conditions	
1.2.F1 Function of Sub-system 1.2		Input Rule (AND/OR) Conditions		
System 2		Input Rule (AND/OR)	Input Rule (AND/OR)	
2.2.F1 Function of Sub-system 2.2		Input Rule (AND/OR) Conditions		
2.1.1.F1 Function of Sub-system 2.2.1			Input Rule (AND/OR) Conditions	
System 3				Input Rule (AND/OR)
3.1.F1 1st Function of Sub-system 3.1				Input Rule (AND/OR) Conditions

Element/Interface Development Mission to System – Example

<u>Development Keys</u>

- Input Rule.
  - Link every function required to support the mission task.
  - Link alternate system functions that support the mission task.
  - Top row for every system defines if the system supports the mission task with a function. (Used later to link system suitability to the task.)
  - Linkages are important since they will be used to evaluate mission tasks based on the evaluation of system functions/suitability.
- Conditions.
  - Consider the conditions based on the ability to support the mission task, but…
  - The specific function may drive the choice of applicable conditions. For example; terrain may effect the communication functions of line-of-sight systems but not effect satellite systems.

MISSION TO SYSTEM LINKS - Unmanned Aerial System (Example)

KEY: SYSTEM and SYSTEM FUNCTION | MISSION TASK | LINKS | CONDITIONS

System	Subsystem	System Function	0.2 Conduct Tactical Operations	0.2.1 Launch UAV	0.2.2 Ingress OA	..	0.2.5 Egress OA	0.2.6 Recover UAV	..	0B.2.4.3A Engage Target
1.0 Ground Control Station			All Functions	All Functions	All Functions		All Func.	All Func.		All Functions
	1.1 Data Link	1.1.F1 Communicate with AV	OR 1.2.F1 1. Terrain 2. AV Altitude 3. EW Jamming	OR 1.2.F1 AND 2.3.1.F1 0.2	OR 1.2.F1 AND 1.3.F1, 2.3.F1 0.2	..	0.2.2 0.2	0.2.1 0.2	..	OR 1.2.F1 AND 3.1.F1 0.2
	1.2 SATCOM	1.2.F1 Communicate with AV	OR 1.1.F1 1. EW Jamming	OR 1.1.F1 AND 2.3.1.F1 0.2	OR 1.1.F1 AND 1.3.F1, 2.3.F1 0.2	..	0.2.2 0.2	0.2.1 0.2	..	OR 1.1.F1 AND 3.1.F1 0.2
	:	:	:	:	:		:	:		:
	1.3 AV Control Station	1.3.F1 Navigate AV			AND 2.3, (1.1 OR 1.2) 1. Flight Profile 2. Weather (Icing) 3. EW Jamming 4. Terrain	..	0.2.2 0.2.2		..	
:			:	:	:		:	:		:
2.0 UAV				All Functions	All Functions		All Func.	All Func.		
	2.3 Air Vehicle	2.3.F1 Fly to Waypoint			AND 1.3, (1.1 OR 1.2) 1. Winds 2. Flight Profile 3. Day/Night 4. Weather (Icing)	..	0.2.2 0.2.2		..	
	2.3.1 ATLS	2.3.1.F1 Control Takeoff and Landing		AND (1.1 OR 1.2) 1. Winds 2. Runway Length 3. Density Altitude		..		0.2.1 0.2.1	..	
:			:	:	:		:	:		:
3.0 Weapon										All Functions
	3.1 Missile	3.1.F1 Guide and Hit Target				..			..	AND(1.1OR1.2) 1. Target Type 2. Weather 3. Slant Range

- Support Documents.
  - Initial Capabilities Document and System Threat Assessment Report to determine conditions.
  - Factors of METT-TC to determine conditions.
  - Integrated architecture products in CDD/CPD uniquely support mission element.
    - SV-5: Maps operational activities (mission tasks) from the OV-5 to the system functions from the SV-4.

Element/Interface Development Evaluation Element

Purpose

- To describe the evaluation measures and how they relate to mission tasks, system functions, and system suitability.

Components

- Conditions: Conditions are assigned to tasks that are linked directly to a MOE in the evaluation element.
- Measure of Effectiveness (MOE): Parameter used to evaluate the system function or mission task.
- Measure of Suitability (MOS): Parameter used to evaluate the suitability of a system.
- Standard: Acceptable performance of the system function or mission task in terms of the MOE or MOS.
- System-focused COI: COI focused on system or sub-system performance. Typically stated, "Does the (system) perform (a specific required capability)?"
- Link to System-focused COI: Column in the evaluation element that identifies which MOE/Ss are used to evaluate the system-focused COI.
- Measure of Performance (MOP): Quantitative or qualitative measure of system performance under specified conditions.

		COI: Does the (system) perform (system capability)?			[0.1] Task 1	[0.2.1] Sub-task of Task 2	[0.n] Task n
S1.S1.P1 MOP for MOS S2.S1		Standard for MOS S1.S1	S1.S1 MOS for System 1	System 1.0	Input Rule (AND/OR)	Input Rule (AND/OR)	
1.1.F1.E1.P1 MOP for MOE 1.1.F1.E1		Standard for MOE 1.1.F1.E1	1.1.F1.E1 1st MOE for Function 1.1.F1	1.1.F1 Function of Sub-system 1.1	Input Rule (AND/OR)		
1.1.F1.E2.P1 MOP for MOE 1.1.F1.E2		Standard for MOE 1.1.F1.E2	1.1.F1.E2 2nd MOE for Function 1.1.F1		Conditions		
1.2.F1.E1.P1 MOP for MOE 1.1.F1.E1		Standard for MOE 1.2.F1.E1	1.2.F1.E1 MOE for Function 1.2.F1	1.2.F1 Function of Sub-system 1.2		Input Rule (AND/OR) Conditions	
S2.S1.P1 MOP for MOS S2.S1		Standard for MOS S2.S1	S2.S1 MOS for System 2	System 2.0		Input Rule (AND/OR)	
2.2.F1.E1.P1 1st MOP for MOE 2.2.F1.E1 2.2.F1.E1.P2 2nd MOP for MOE 2.2.F1.E1		Standard for MOE 2.2.F1.E1	2.2.F1.E1 MOE for Function 2.2.F1	2.2.F1 Function of Sub-system 2.2		Input Rule (AND/OR) Conditions	
0.2.1.E1.P1 MOP for MOE 0.2.1.E1		Standard for MOE 0.2.1.E1	0.2.1.E1 MOE for Task 01			Conditions	
0.n.E1.P1 MOP for MOE 0.n.E1		Standard for MOE 0.n.E1	0.n.E1 MOE for Task 1.2.F1				Conditions

Element/Interface Development Evaluation Element – Example

Development Keys

- Mission and System Elements.
  - All system functions must have at least one MOE.
  - Mission tasks linked directly to a MOE usually indicate a need for evaluation during OT&E.
- MOEs, MOSs and MOPs.
  - System functions and mission tasks may have more than one MOE.
  - MOEs may have more than one MOP.
  - Both systems and sub-systems may have one or more MOSs.
  - "Dry run" evaluation from MOP to mission task to ensure evaluation is sound.

EVALUATION ELEMENT - Unmanned Aerial System (Example)

KEY: MISSION TASK; LINKS; CONDITIONS; SYSTEM & FUNCTION; EVALUATION; CONDITIONS

COI: Does the missile guide, fly to and impact the target in its intended operating environment?

COI: How capable is the UAS equipped unit in supporting the Commander's RSTA and Armed RSTA requirements in an operational environment?

Mission tasks: 0.1 Plan Mission; 0.2 Conduct Tactical Ops; 0.2.1 Launch UAV; 0.2.2 Ingress OA; ..; 0.2.3.3 Locate Targets; ..; 0B.2.4.3A Engage Target

Measures of Performance	Standards	MOE/MOS	System	Function
S1.S1.P1 # Failures	> 100 hrs ***(KPP)***	S1.S1 MTBMEF	1.0 Ground Control Station	
1.1.F1.E1.P1 % of accurate sent messages.	> 90.0% ***(KPP)***	1.1.F1.E1 Data Accuracy		1.1.F1 Communicate with AV
1.1.F1.E2.P1 % of complete messages.	< 5.0%, < 30 seconds **(Attribute)**	1.1.F1.E2 Drop Out Rate		
1.1.F1.E2.P3 Time of drop out.				
:	:	:		:
1.3.F1.E1.P1 % via direct route.	Military Judgment	1.3.F1.E1% of Successful Course Changes		1.3.F1 Navigate AV
1.3.F1.E1.P2 % via waypoints.				
:	:	:		:
S1.S1.P1 # Failures	> 100 hrs ***(KPP)***	S2.S1 MTBMEF	2.0 UAV	
2.2.F1.E1.P1 Stationary Targets	> xx.x % at XX km ***(KPP)***	2.2.F1.E1 % of Targets Detected		2.2.F1 Detect Target
2.3.F1.E1.P1 Difference between estimated and actual time of arrival.	< 10 sec from estimated time of arrival **(AA)**	2.3.F1.E1 Waypoint Arrival On-Time %		2.3.F1 Fly to Waypoint
2.3.1.F1.E1.P1 % of Successful T/O	Must Control YES/NO **(AA)**	2.3.1.F1.E1 % of Successful T/O		2.3.1.F1 Control Takeoff and Landing
2.3.1.F1.E2.P1 % of Successful Landings	Must Control YES/NO **(AA)**	2.3.1.F1.E2 % of Successful Landings		
:	:	:		:
S1.S1.P1 % Failed Missiles	> 100 hrs ***(KPP)***	S3.S1 In-flight Rel.	3.0 Weapon	
3.1.F1.E1.P1 % targets hit.	Performance similar to AGM-xxx	3.1.F1.E1 Probability of Single Shot Hit		3.1.F1 Guide and Hit Target
:	:	:		
0.1.E1.P1 Time to plan.	Military Judgment	0.1.E1 % of Successful Mission Planning Sessions		
0.1.E1.P2 % successful loads.				
0.2.3.3.E1.P1 % operational targets detected.	> xx.x % at XX km ***(KPP)***	0.2.3.3.E1 % of Targets Detected		

- Standards.
  - Assign a standard to each MOE to assist in resolution of the MOE. Typically four types of standards:
    - Direct Measurement: Compare demonstrated performance to standard. For example; maximum range.
    - Pass/Fail: Demonstration of a particular feature. For example; required number of hard points.
    - Comparison: Compare performance of two systems. For example; "performance equal to or greater than…"
    - Military Judgment: No specific standard. Military utility will be determined after the evaluation.

Element/Interface Development Test Element

Purpose

- To describe the data products, the sources of the data products, and how they relate to the evaluation element's MOPs.

Components

- Link to MOPs: Description of which data products support which MOPs.

- Data Products: Specific data packet obtained though a data source satisfying a MOP data requirement.

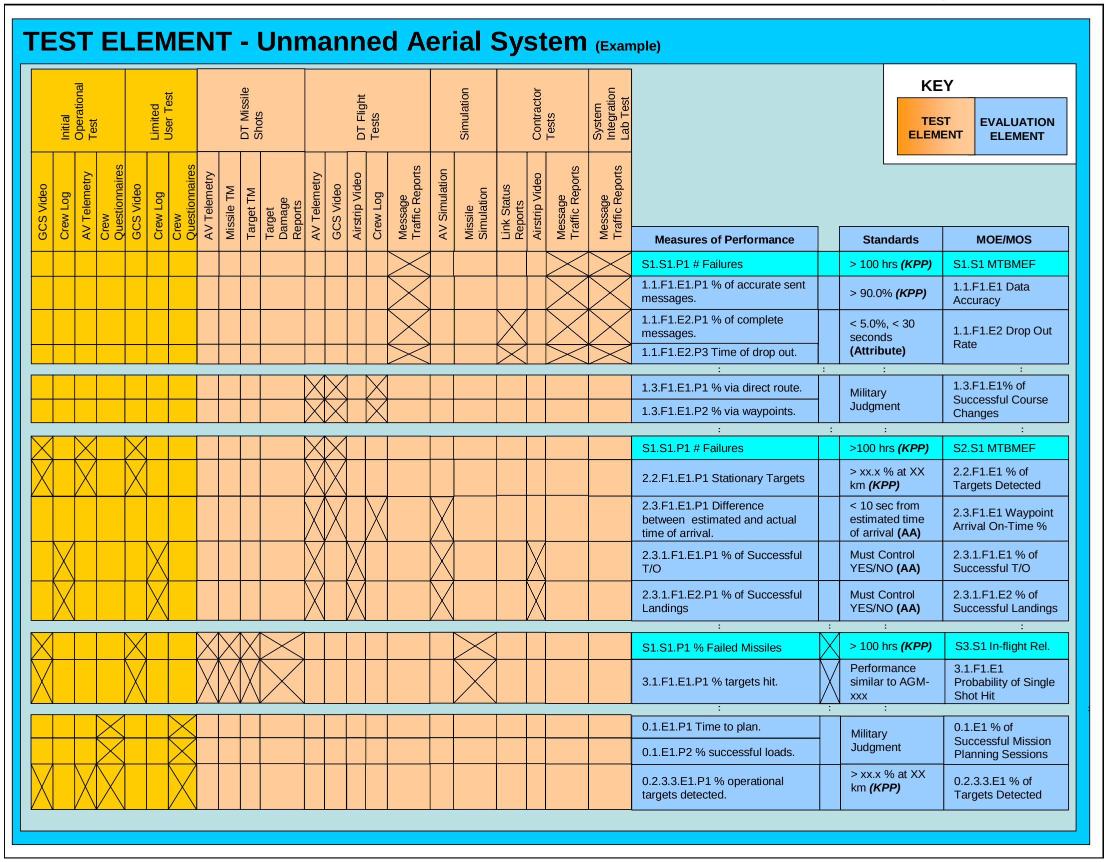
- Data Sources: The specific source of a data product.

Operational Test Event #2		Operational Test Event #1			Modeling and Simulation	Developmental Test			Contractor Test		← DATA SOURCE
Data Product #1	Data Product #2	Data Product #1	Data Product #2	Data Product #3	Data Product	Data Product #1	Data Product #2	Data Product #3	Data Product #1	Data Product #2	MOPs
							X			X	MOP S1.S1.P1
X			X		X		X		X		MOP 1.1.F1.E1.P1
						X					MOP 1.2.F1.E1.P1
					X						MOP S2.S1.P1
								X			MOP 2.2.F1.E1.P2
	X	X		X							MOP 0.2.1.E1.P1
	X			X							MOP 0.n.E1.P1

Element/Interface Development Test Element – Example

Development Keys

- Data Products.
  - Data requirements for each MOP are translated into the data products.
  - Requirements should be of sufficient detail to provide the scope of the effort that will generate the data product.
  - Each MOP must have at least one data product.
  - More than one MOP can be supported by a data product.



- Data Sources.
  - Data sources can include: contractor tests, developmental test, operational tests, field exercises, and modeling and simulations.

- Evaluation Strategy.
  - The test element describes an integrated test program.
  - The test element also provides a method to view the acceptability of the entire evaluation strategy.
    - Are the data products sufficient to evaluate the MOE/MOS standard?
    - Which functions/tasks are demonstrated solely in DT?
    - Are there any functions/tasks that are not demonstrated prior to OT? Is this acceptable?

Element/Interface Development Mission Test & Evaluation Plan

- Documents the four elements and the interfaces between them.
- Two main body chapters: mission evaluation and data sources.

MISSION EVALUATION CHAPTER

Mission
Description of the overall mission.
- **Mission Task**
  Description of the mission task.
  System functions input rule.
  Conditions.
  - Measure of Effectiveness
    Description of the MOE.
    Evaluation Design and Procedure.
    Standard.
    - Measure of Performance
      Description of the MOP.
      Method of Analysis.
      - Data Product (s)
        Listing of required data product (s).
- **System**
  - MOS; MOP; Data Product (s).
  - System Function
    - MOE; MOP; Data Product (s).

DATA SOURCES CHAPTER

Data Sources
Summary description of all data sources.
Summary data product schedule for all data sources.
- **Data Source**
  Purpose and description of the data source.
  Scope and schedule of the data source.
  - **Data Products**
    Description of the data product.
    Listing of the MOPs requiring the data product.

Application
Test and Evaluation Elements

- Test Element:
  - Data is collected from the data sources.
  - Data is then authenticated in terms of quantity, quality and applicability.
  - Authentication body (Data Authentication Group) includes representatives from the test events, other data sources, the evaluator and materiel developer.

- Evaluation Element:
  - Data is then organized and analyzed.
  - Each MOE/S is rated as **<u>met</u>** or **<u>not met</u>** based on the standard.

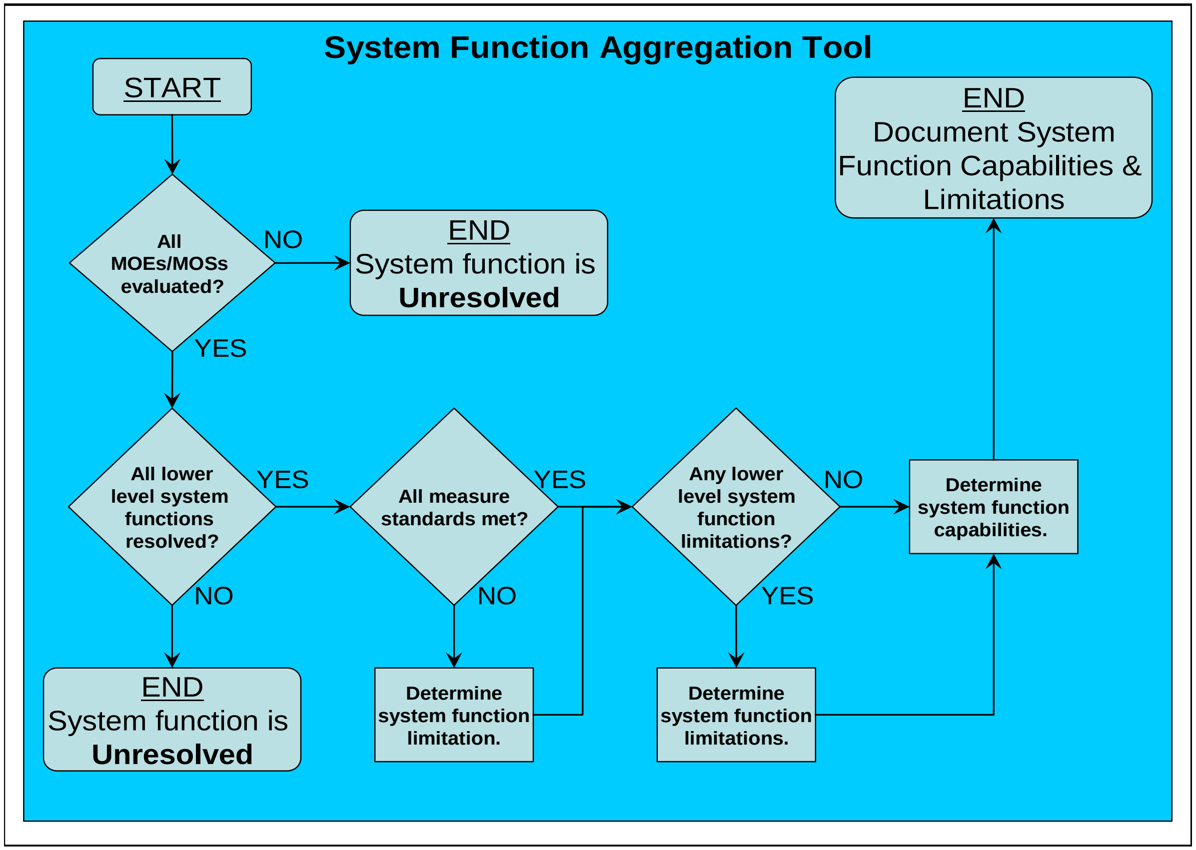
Application System Element

- System function **capabilities and limitations** are determined at the System Element.
  - Capability: "The (system) has the capability to (function capability with reference to standard)."
  - Limitation: "The (system) is limited to (function capability) which is (shortcoming with reference to the standard)."

- MOE/MOS ratings are applied to the system functions to determine the system capabilities and limitations.

- Capabilities and limitations of lower level system functions are also used to evaluate higher system functions.

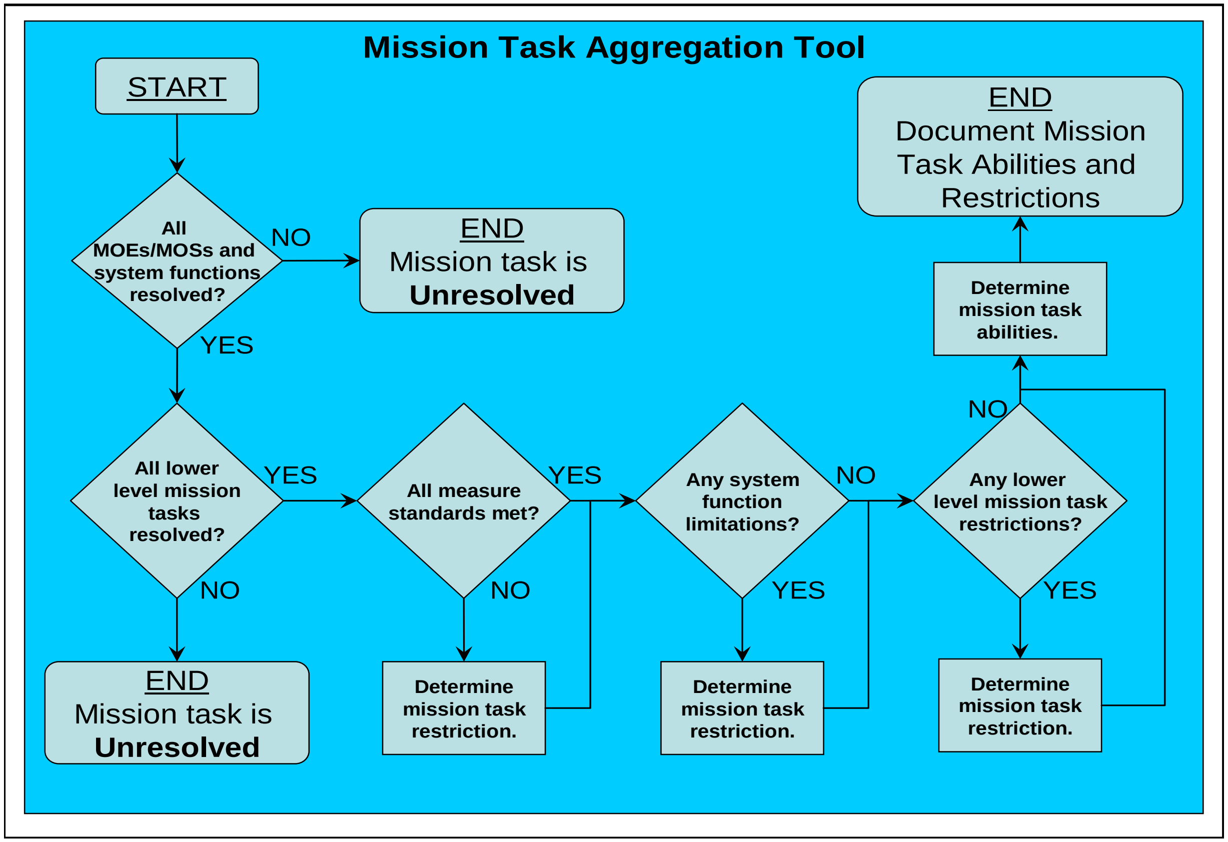
- Tool developed to resolve the system functions.



Application
Mission Element

- Mission task **abilities and restrictions** are determined at the Mission Element.
  - Ability: "The (unit) has the ability to (task ability) while (task)."
  - Restriction: "The (unit) is restricted to (task ability) while (task) which is (shortcoming to mission task requirement if available)."

- MOE/MOS ratings are applied to the mission tasks to determine the mission abilities and restrictions.
- System function capabilities and limitations are used to determine mission abilities and restrictions.
- Abilities and restrictions of lower level mission tasks are also used to evaluate higher mission tasks.
- Tool developed to resolve the mission tasks.



Application
Mission Evaluation Report

- MER provides the documented results of the evaluation.
  - Mission Evaluation Results.
    - Mission Performance in terms of Mission Threads.
    - Overall Mission Abilities and Restrictions.
    - Individual Mission Task Abilities an Restrictions.
  - System Evaluation Results.
    - System Performance in terms of Attributes and KPPs.
    - System Suitability
    - Overall System Capabilities and Limitations.

Provides the decision maker with…

a clear picture of the system capabilities and limitations allowing acquisition decisions based on the military utility gained.

Provides the warfighter with…

a clear picture of the unit's abilities and restrictions within the context of the mission.

Weaknesses

- Process is time consuming to plan and execute.
  - Requires extensive planning effort across functional boundaries (user, materiel developer, T&E).
    - "Sharing the burden" of developing the different elements with user, materiel developer and tester/evaluator can mitigate the impact. This also develops a consensus of the T&E strategy.
    - Database application software can be used as a tool to facilitate organizing elements and interfaces.
  - May require interpretation of results to determine capabilities/limitations and abilities/restrictions.
    - "Sharing the burden" again can be used. This develops a consensus of the results.
- Not all information required to develop the elements is available at early system development milestones.
  - Systems in development prior to Milestones B may still be in competition.
    - Defining system items and functions in a generic sense can be used. System design specifics would be added after contractor selection. Also, generic system functions supports evaluation of technological risks.

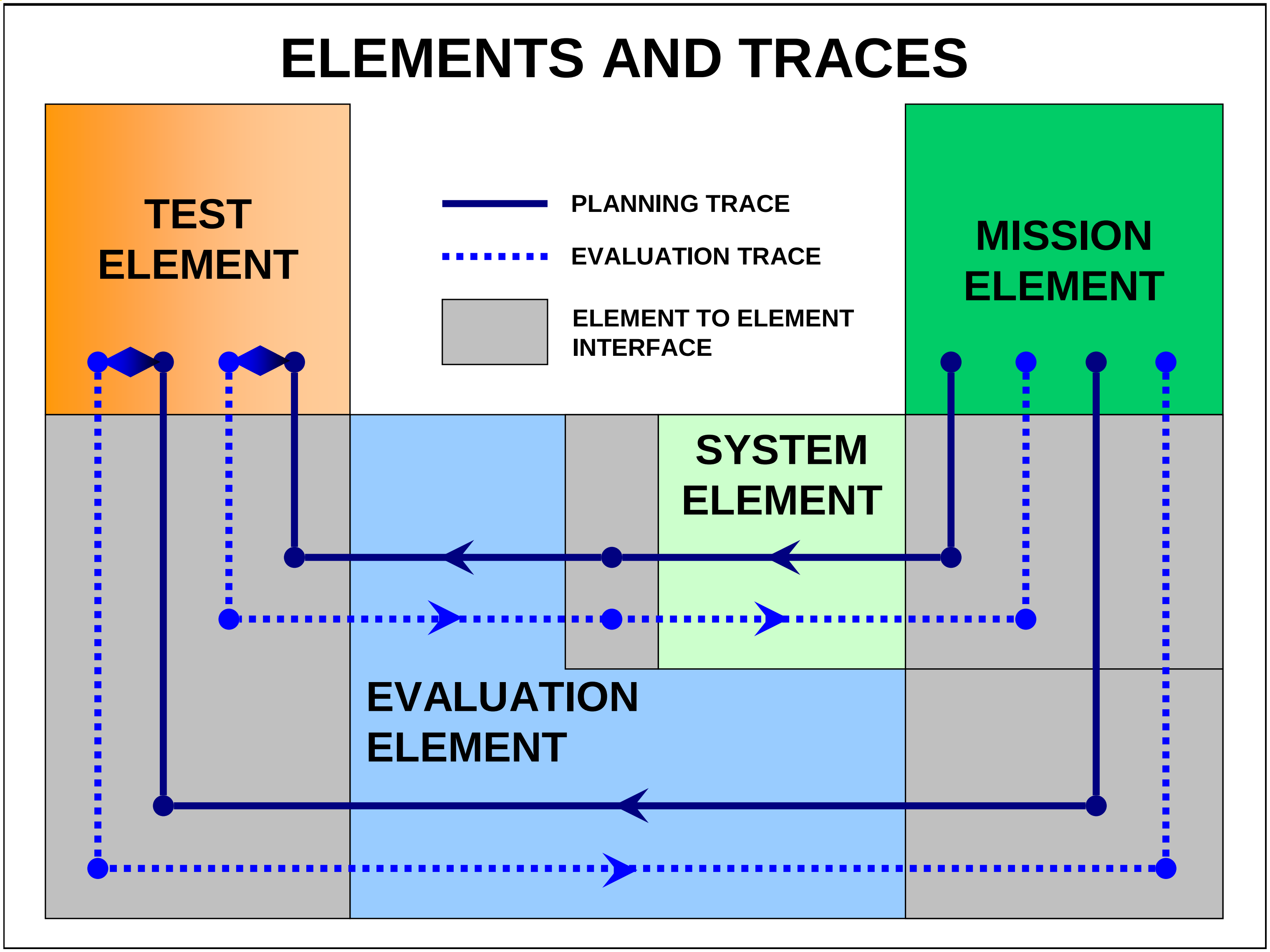
Strengths

- Provides a mission-based form of evaluation.
  - Military utility of the system immediately apparent to the user.
  - System suitability directly linked to mission capability
- Outlines a fully integrated test and evaluation program.
  - Promotes synergistic use of data gathered from all sources: contractor test, developmental test, operational test, and modeling and simulation.
  - Promotes early identification of T&E strategy risks.
- Provides continuous evaluation of the mission throughout all system development phases.
  - Impact of development risks on the mission visible in early development.
  - Monitors progress of system development and demonstration within the context of mission abilities provided.
  - Incremental development strategies are supported by evaluating each increment's abilities in the context of the overall mission.

Summary

- Mission-based evaluation process has been developed to support T&E planning and execution. Process is comprised of:
  - Four elements.
    - Mission Element: Comprised of the mission tasks and sub-tasks.
    - System Element: Comprised of system items and functions.
    - Evaluation Element: Comprised of the evaluation MOEs and MOPs.
    - Test Element: Comprised of the data sources and products.
  - Interfaces.
    - Links between each element have been developed to facilitate T&E planning and execution.
- Execution of the T&E effort provides:
  - the decision maker with a clear picture of the system capabilities and limitations allowing acquisition decisions based on the military utility gained.
  - the warfighter with a clear picture of the unit's abilities and restrictions within the context of the mission.

Element, Links & Traces



Acronym Chart

AA	Additional Attribute
AV	All View (slide 4)
AV	Air Vehicle (slides 11, 13, and15)
CDD	Capabilities Development Document
COI	Critical Operational Issue
CPD	Capabilities Production Document
DAG	Data Authentication Group
DoD	Department of Defense
DT	Developmental Test
GCS	Ground Control Station
JCIDS	Joint Capabilities Integration and Development System
KPP	Key Performance Parameter
MER	Mission Evaluation Report
METT-TC	Mission, Enemy, Terrain, Troops, Time and Civil
MOE	Measure of Effectiveness
MOP	Measure of Performance
MOS	Measure of Suitability
OA	Operational Area
OT	Operational Test
OT&E	Operational Test and Evaluation
OV	Operational View
RSTA	Reconnaissance, Surveillance & Target Acquisition
RT	Remote Terminal
SATCOM	Satellite Communications
SV	Systems View
T&E	Test and Evaluation
T/O	Takeoff
TM	Telemetry
TV	Technical View
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

NDIA ADDRESS

6th Draft
(Text Only)
3/12/07

Thank you for that nice introduction. It is indeed a pleasure and an honor to be here today and to contribute to this ongoing conversation about how all of us can work together to improve the products and services we provide our nation's defenders and first responders. Underwriters Laboratories has a long history supporting national defense and homeland security. We also have a long history with many of the companies and organizations here today, both in the private sector and public security arenas. At the same time, we have little direct NDI experience and our Homeland Security business is relatively new so what I can best do today is to share with you our business model for our Core Business and hope that there is a Best Practice or two than can be directly applicable to your work.

Our security division was founded in the 1920s during the gangster wars in Chicago, when we published standards for stronger safes, more secure locks and bullet-resistant glass. During War World II, UL was classified as an "essential industry". We tested devices to protect US plants from sabotage and trained military personnel in fire protection and general safety.

Today, we continue to work with NDI affiliates, auditing security systems at facilities, undertaking basic research to advance the safety and training of first responders, and, of course, testing and certifying products that contribute to the safety and well-being of those who protect us and the public at large. It is a part of our business of which we are very proud.

As most of you know, UL is an independent, not-for-profit product testing and certification organization dedicated to public safety. For over a hundred

years, UL has played a central role in creating and maintaining a culture of product and public safety in the marketplace — a global culture that extends to designers and engineers, manufacturers and their suppliers, wholesalers and retailers, and to the consumers who purchase these products.

Today, I would like to explain to you how this safety model works and share with you some valuable lessons we've learned over the years. I will also suggest ways this model could be applied throughout defense and homeland security, to assure quality and sustainability in a competitive market. In fact, I do think that "quality and sustainability" go hand-in-hand with safety..

UL first got into the testing and certification business over a hundred years ago. It all started at the 1893 World's Fair, the Columbian Exposition in Chicago. One of the main attractions at the exhibition was the Palace of Electricity. This was a big deal. For the first time in history, the harnessing of this new technology called electricity was being displayed for the entire world to see.

The problem was, fires were breaking out all over the place. Frequently. So the company that was insuring the Palace of Electricity called in a young engineer from Boston, William Henry Merrill to address the problem.

Merrill brought with him a set of "best practices" for wires, switches and insulation that he applied throughout the exhibition, which, in turn, became a huge success in showcasing this new technology. Pretty soon manufacturers found out that the young engineer was doing this kind of work, so they would bring their products to him to make sure they were safe. That's how UL got started and how William Merrill became our founder and first president.

I mention our founding because it clearly demonstrates the natural formation of an environment that ensures quality, sustainability and safety. On the one hand you had manufacturers who wanted to sell this new technology, but on the other hand you had the authorities having jurisdiction — the insurance companies, the

building owners, and ultimately, the end-users, who needed to know that the product works safely. As an independent voice, UL was able to bridge that gap and facilitate the market.

The key, then, to creating and maintaining a culture of product and public safety is the complete participation and collaboration of all members of the marketplace.

Essential, too, is the right private-government partnership. In the US the Consumer Product Safety Commission has broad latitude to mandate safety standards and testing. However, they have always had the perspective that voluntary industry compliance to standards and independent third party testing is preferable to government mandated standards and testing; always with the 'big stick' of government mandate should industry fail to do the right thing. Thus, CPSC always states their policy that compliance to standards and independent conformity assessment testing is 'Voluntary but not Optional'. It is an excellent working model that protects the public, ensures a level playing field in the market, and leaves business unfettered to innovate.

The critical elements involved in assuring product safety in a competitive market are:

- the development of safety standards to protect those who use the product.
- conformity assessment systems which test products against those standards and certify that they are compliant.
- Rigorous factory follow-up services to confirm continued compliance after certification is obtained

- rigorous anti-counterfeiting efforts to protect the certification, the manufacturer who invests in it, the authorities having jurisdiction who demand it, and the end user who depends on it.

- and finally, education and training throughout the marketplace.

You can think of standards as the ‘rules of the game’ and conformity assessment and follow-up services as the ‘referees’. If you imagine a football game with no rules and no referees then you have a good picture of what many commercial markets would look like without standards, conformity assessment and follow up services – especially in a rapidly globalizing market with many emerging country participants/

Let’s take a closer look at each of these elements and the role they play in the safety model. First, the development of standards.

A standard is a set of requirements or codes to improve a product’s safety and, in some cases, efficacy as well. A standard takes into account product usage, the environment under which it will be used, and the harsh conditions it may encounter and still remain functional. This is true for the motor of a vacuum cleaner, the sprinkler head of a fire suppression system or the electrical safety of a string of decorative lights – one that can work in a Minneapolis Christmas and a Miami Christmas. Standards can be broadly encompassing – for example a DVD Player standard would include electrical safety, mechanical safety to ensure that small fingers don’t get injured by the moving parts, and EMC emission and susceptibility – perhaps performance testing too.

Standards allow manufacturers to confidently invest in product development knowing they will have a market that trusts the safety and efficacy of their products. Standards increase competition and encourage innovation. Standards level the playing field. When all products meet certain requirements, price and

special features become the points of differentiation, rather than whether they are safe for use.

In the past, UL wrote and published standards in a more or less closed forum. In the last 10 years or so, this process has become much more open. Today, more and more standards are being written by committee. Technical panels, consisting of government, industry, consumer, and UL representatives, are meeting together to develop and evolve the standards. This is a good thing. Collaboration and participation is encouraged at every level in the development of safer products.

The first step in determining a standard is, then, assembling an expert panel who will then bring the knowledge needed to create the best set of requirements to achieve the goals of quality, sustainability and safety. A standard must be rigorous and practical — in that it has real world application, so manufacturers know they can practically produce a product that conforms to the standard. We have found that when we bring all stakeholders together, they are quite willing to put all their thoughts, opinions and ideas on the table and go through the pull and tug process of working toward the best solution. By achieving consensus, participants go away from the process saying ‘maybe I didn’t get everything I wanted, but I have to admit that we ended up with the best set of requirements’. And once a standard is published, all of us continuously look at real world application and new technologies that can change and improve the standard. Standards are living documents.

Once a standard is accepted the next element in our safety model comes into play, Conformity Assessment.

Conformity Assessment is the process of determining that a product conforms to a standard and that it continues to remain compliant. There are six functions involved in Conformity Assessment:

The testing function involves the tasks that gather and record the data needed to make determinations of compliance. The tasks include, but are not limited to developing a test plan, conducting laboratory testing, recording test results, making physical measurements of product characteristics and reviewing markings and accompanying documents. Consideration must also be given to the need for accreditation of the laboratories conducting the testing. Laboratory accreditation is essential to ensure confidence in and consistency of test results.

The determination of compliance function compares the information and data gathered during testing to the technical requirements to make a decision if that information and data demonstrates compliance with requirements.

Conformity can be self-declared or assessed by 3rd parties. The form of this is a suppliers declaration of conformity when done by the manufacturer and the certification function – a Mark - when conducted by an independent third party or government. This attestation normally takes the form of a supplier's declaration of conformity document when the conformity assessment is conducted by the first party and a certification mark when issued by an independent third party. When the government is the conformity assessor the attestation can come in a variety of different forms such as formal letters from regulatory agencies and/or on product marks.

Factory inspection is a pre-market mechanism that confirms compliance of on-going production. It usually involves physical inspection of products in production, verifying components, evaluation of production testing equipment/procedures and a review of the quality system its implementation and, often, sample testing. Results of factory inspection can be used to prompt/direct corrective actions or even to stop shipments when needed.

Market Surveillance is a post-market function directed at validating the conformity of products that are available in the market. Tasks include testing and inspecting products obtained from the market to verify their compliance with technical requirements and the attestation of conformity made by the supplier, independent third party or government following the initial determination of compliance. Results of market surveillance can be used to prompt corrective actions, improvements in the conformity assessment system and/or technical requirements when needed.

Corrective action is the function that addresses tasks involved with addressing non-conforming products before they reach the market as well as misuse of the attestation of conformity. The tasks involved may include issuing public notices, conducting recalls and/or restricting the use of certification marks.

UL has conducted conformity assessments for over 70,000 manufacturers in 96 countries. In 2005 alone UL staff evaluated over 19,000 different types of products. We also conducted over 500,000 on-site factory follow-up visits to check on manufacturers' continuing compliance with product certification requirements.

Conforming to standards and conformity assessments require significant investments in time and money. For this reason, it is extremely important to protect those who play by the rules from those who don't.

Trademark counterfeiting is estimated at $500 billion annually or roughly 5%-7% of global trade. Counterfeiting is a growing threat to every industry. I can tell you, UL is an organization that goes to great effort and expense to stop it.

Our Anti-Counterfeiting Operations has two main objectives: first, to help protect the welfare and safety of consumers around the globe, and second,

to protect the integrity of the UL Mark and all that it stands for. UL does not tolerate the counterfeiting of its Marks and takes swift and definite action against those engaged in this criminal activity. Consumers and our customers should expect their safety certifier to have a zero-tolerance policy when it comes to counterfeiting.

UL has one of the most comprehensive intellectual property training programs in the world: We train personnel at 40-50 US Customs ports every year and we conduct law enforcement training seminars around the globe. Our aggressive program has trained over 2500 law and code enforcement officials since our program's inception in 1995. On average, there are more than 100 US Customs seizures each year of products bearing counterfeit UL-marked products—with retail values estimated at over $12 million. Our training programs are working.

We are taking the fight to the counterfeiters – working on the task forces of the FBI, Interpol, the World Customs Organization, and the International Trademark Association. We are involved in ongoing surveillance and raids – striking at the heart of the problem in China and South America. We are also partnering with the Royal Canadian Mounted Police combating counterfeits in their marketplace. And we're working closely with our customers and industry trade associations to help them understand the scope of this problem and assist them in the development of their own anti-counterfeiting programs.

Finally, yet equally important in our safety model, is the education and training of each and every entity in the marketplace, from manufacturers and their suppliers, to acceptance authorities, to end-users.

UL University offers our customers over 1,500 courses providing safety standards training in areas such as Medical Devices, Medical Software,

Industrial Control Panels, NEC, Plastics, Fire Safety, Hazardous Locations, Quality Training, OSHA, ITE and many more. We have a Hazard-Based Safety Engineering curriculum that helps engineers design safety into products by anticipating user behavior and related hazards. We teach our customers how to integrate quality and safety into their products by design.

For acceptance authorities, we provide seminars that emphasize the importance of purchasing products that are certified as compliant with safety standards; what to look for when buying or receiving products covered by UL requirements; and how to detect and prevent counterfeiting of the UL Mark.

And for end-users, the general public, we utilize mass media, we conduct in-store promotions; we go into schools and universities with consumer education and awareness programs and we support programs that teach safety; how to use these products safely; even, how to live safely, at home, at work and in public spaces. For example, we support the Center for Campus Fire Safety which teaches young people how to avoid dorm fires, how to escape them when they occur and how to use basic safety equipment like a fire extinguisher.

This is our model for assuring safety in a competitive market. At UL, we are incredibly proud of our role in bringing safety to the marketplace and the countless lives that have been saved and injuries that have been prevented here at home and around the world. It is a model that has proven to be extremely effective over time. And it is a model that we believe can be used by defense and homeland security to help assure quality and sustainability in a competitive market.

Recent events both at home and abroad have put immense pressure on the NDI community and have created an environment that can affect the performance and life-cycle costs of products. Namely:

- a high demand for new products and services

- a rush to market to meet that demand
- and the deployment of existing products in environments and for usage for which differ from their original design intent.

The DoD, for the first time last year, spent more on maintenance and repair than on procuring new equipment. While certain performance issues may be unavoidable in these unpredictable times, it can be argued that with a more rigorous infrastructure in place, many instances of poor performance could be mitigated — if not immediately, then quickly.

Now I want to say that this is not the first time UL has presented the inner workings of product and public safety to the defense and homeland security industry. On many occasions, Federal officials have come to our offices to learn about the regulatory infrastructure that fosters safety. We have heard many times, “This is what we need” and “How can we do that?” And we say, all you have to do is to determine that this is what you want. You are the manufacturers authorities having jurisdiction and, just as the insurers and building owners told the electrical manufacturers decided over a hundred years ago, you too can demand that the products and services your industry produces and uses meet a set of requirements, a standard, that can be tested and certified, which will assure quality and sustainability in a competitive market.

Clearly the national defense industry is different from the civilian marketplace. And we recognize a very significant difference between defense and homeland security. That being said, however, there is an infrastructure in place, as I have just shown you, which can conform to the unique needs of defense and homeland security. An infrastructure that can help the industry produce standards, test for compliance, prevent counterfeiting, and educate and train all entities involved in defense and homeland security.

So let's take a look at our safety model once again and discuss ways that it can be applied to the NDI community. First, the development of standards.

The first thing NDI can do is review applicable and existing private sector standards and technical regulations that cover specific types of usage beyond typical commercial application. Where standards lackn requirements for such usage, new ones can be developed.

Second, agree on and create conformity assessment and follow-up service models that suit your industry.

Third, agree on and create a Marking system that suits your industry.

In the safety model, standards often are developed through balanced, consensus-based, and transparent forums. This is a time-consuming process, but one that is right for the private sector— not necessarily for your industry.

For reasons of both speed and security, standards can be developed in a closed forum. The companies and organizations here today represent world leaders. Ten of your people could sit down and in the course of a few months develop appropriate requirements that address usage, environment, life cycle and other objectives.

In some cases, for security reasons, a standard may never be openly published. However, it is advisable, whenever possible, to make a standard as open as possible — available to as many companies as possible. Competition leads to innovation and innovation ultimately drives down costs. Additionally, published standards send two very clear signals to the business community. One, that everybody will be producing to the same standard, and two, there will be a readily accepting market for their products. Every

time you publish a standard you are assuring quality, sustainability and safety in that market.

There is one more thing I would like to say about standards developed for Homeland Security. In addition to requirements that address functionality, product safety requirements should be part of the standard. Those who have the authority to purchase homeland security products — such as fire departments, airport authorities, and transportation authorities, at the local, state, and federal levels —need to know that the products they are using are not only effective, but also that they will not cause harm to the general public from their usage. In a recent poll, ninety-seven percent of electrical, building and fire AHJ's, ninety-seven percent, said they can accept UL certified products without additional steps. When they see UL, and they know it meets their safety requirements.

Conformity Assessment systems in the NDI community, like developing standards, may vary from product to product. When conformity assessment is desired we would see a two-track solution; using third parties like UL for Safety, Environment and Life Cycle Assessment and using DoD and DoE facilities for assessing functionality. Why do we recommend this approach? Simply, it is to apply the best resources to the task. For example to assess the functionality of products such as CBRNE detection devicesthere are only a few places in the US where you can test a biological detection device. As much as we are committed to safety I can say that neither UL nor anyone else in our industry is likely to get excited about testing with Anthrax and I suppose that you would also prefer that we not have such materials in our labs. Once functionality is established, an identical device should be tested for safety. Will the device work 24/7. Can it handle electrical surges? Will it cause shock or fire if it gets wet? Is the mounting device sufficient to

protect those who walk under it? These are all issues that need to be considered when deploying these types of products in public spaces.

In most instances, where product contracts will be awarded to multiple vendors, it is advisable to utilize 3rd party conformity assessment, to verify consistency in the quality of all product coming off the line.

3rd party Conformity Assessment brings value to all members of the NDI community. For manufacturers, it enables International Market Access and provides continued assurance that products will be accepted by AHJs and other stakeholders. For AHJs, 3rd party Conformity Assessment provides a "level-playing field" of proven requirements instead of manufacturer assertions and unverifiable performance claims. And for Homeland Security and Defense entities, requiring 3rd party Conformity Assessment ensures performance-based standards and related requirements are consistently met for products. And, as I have stated, this is not re-inventing the wheel. Ready-made 3rd party Conformity Assessment processes are available today, into which DHS and DoD may plug in its broad set of needs and specify products that meet listing requirements.

Now let me talk about counterfeiting and how it could affect your community. Today, in China, a sprinkler head is being manufactured with the UL mark on it that looks exactly like the sprinkler heads of legitimate suppliers. They are being installed in buildings but they don't work in extreme environments – like in a fire. Which is quite a scary thing. If a group of unseemly players takes the time to knock off a product that costs a dollar fifty, what's to stop a counterfeiter from knocking off a five thousand dollar box that intended to protect Homeland Security. Especially in the Homeland Security marketplace, it is essential that an anti-counterfeiting program be put in place to protect the public and the legitimate players in the market.

Education and training is the glue that holds our safety model together, that keeps everybody working on the same page. And it should play an important role in maintaining quality throughout your marketplace.

As I mentioned at the beginning of my address, UL has a long history supporting defense and homeland security and we continue to be an active player in this arena. We believe this role can be expanded. We have an infrastructure in place — the resources, facilities, people and processes — that can help the NDI community reach its goal of sustaining quality in a competitive market.

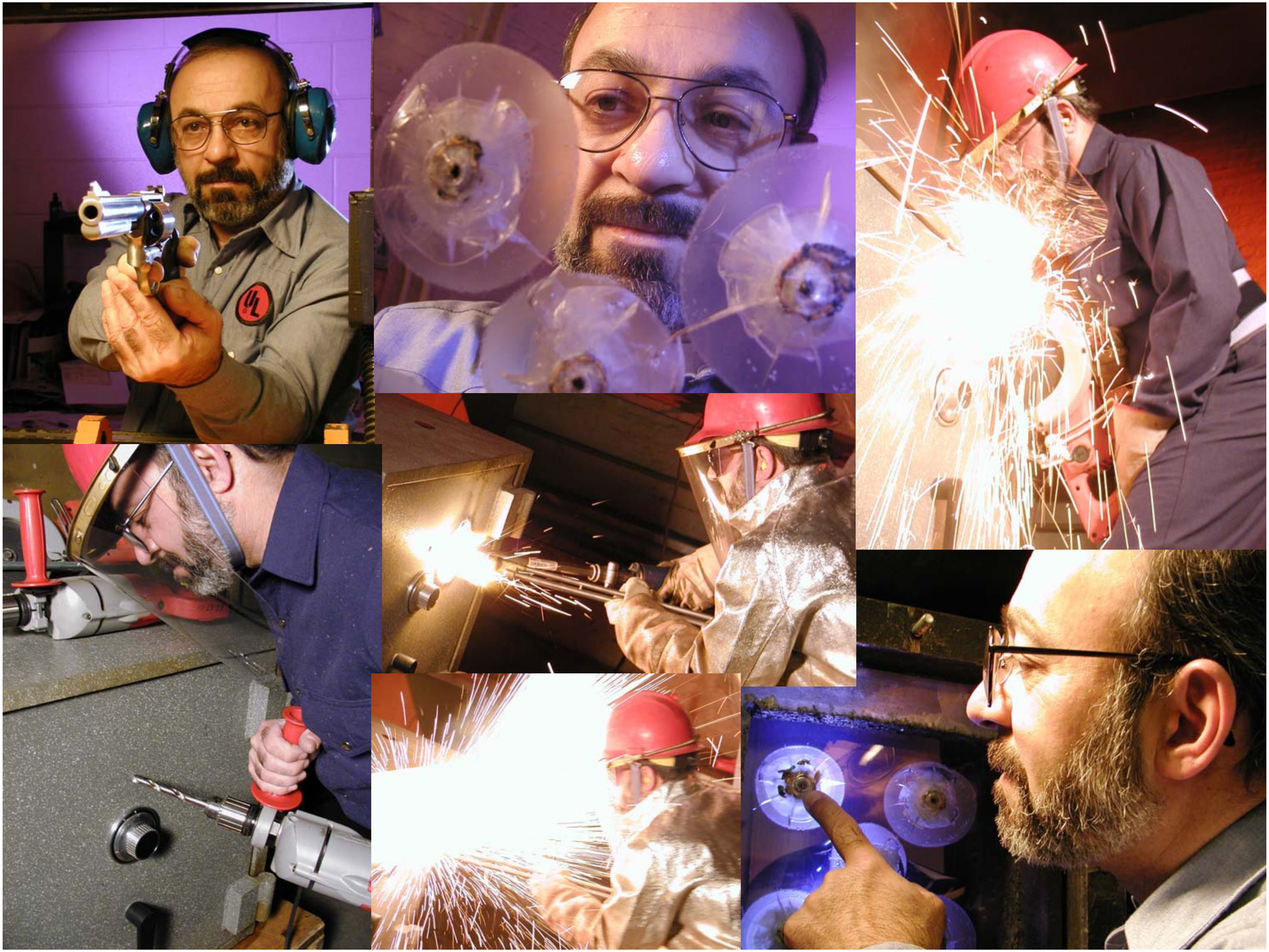
Now I realize a presentation such as this perhaps raises more questions than it does provide solutions. So I look forward to answering some of your questions, along with Dr. McQueary, after his presentation. But before I close, I just want to say, and I think I can speak for everyone here today, and say that nothing is more important than providing our war fighters and first responders with the highest quality equipment and services they need to accomplish their missions and which will protect them in the process. Nothing is more important than protecting citizens with the products and services we all need to keep us as safe and secure as possible here at home. Anything less is a disservice to those who put their lives at risk and to the American taxpayers who pay for the products and services that we provide.

I will say it once again. The organizations here today represent world leaders. Your ingenuity, resourcefulness and dedication continue to produce technological advancements that provide an extraordinary service to our country.

I truly believe that working together we can create, maintain, and sustain a culture of quality that continuously and predictably produces products and services that meet the needs of those who protect us. Thank you

Assuring Quality and Sustainability in a Competitive Market

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

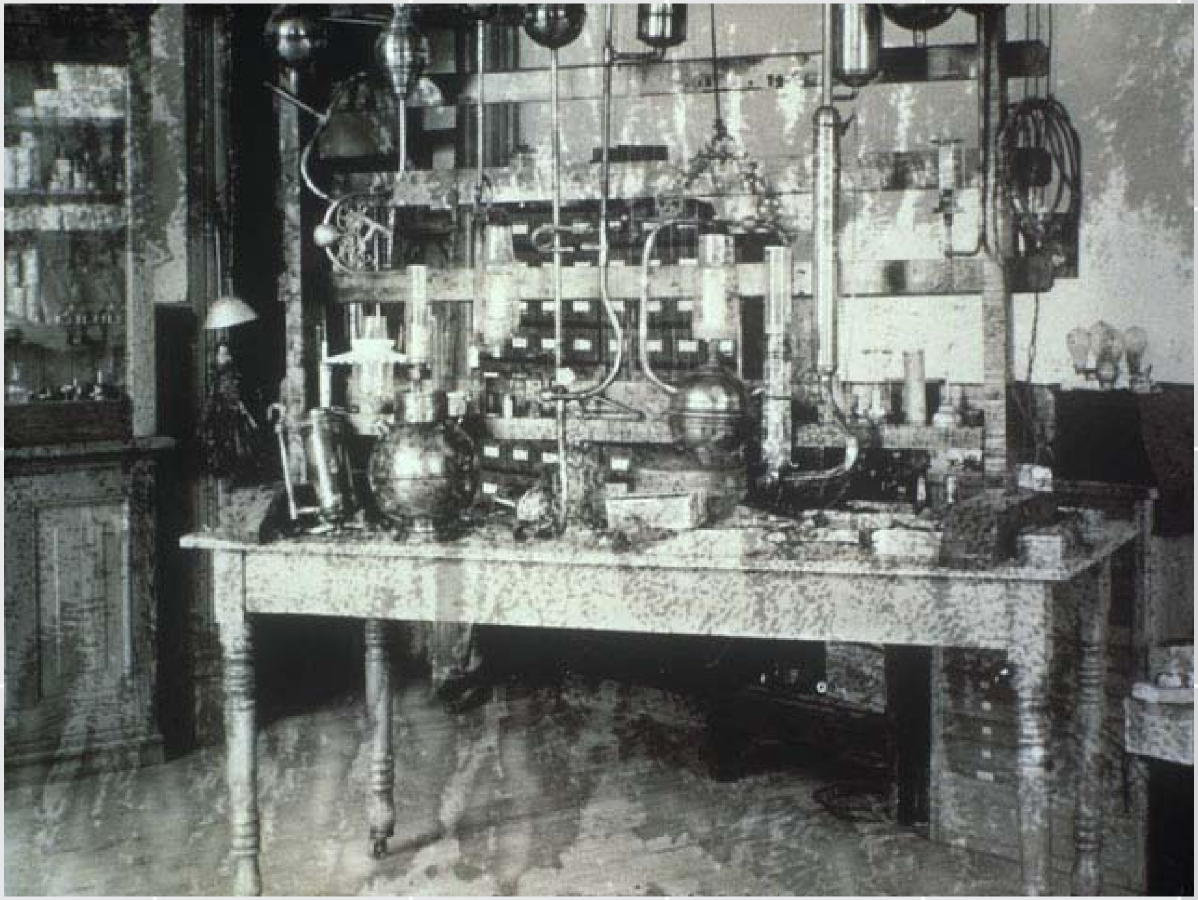

UL


LABELED
PRODUCTS
DANGER
13.500 VOLT

Assuring Quality and Sustainability in a Competitive Market

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY



Assuring Quality and Sustainability in a Competitive Market

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Assuring Product Safety in a Competitive Market

- Development of Standards
- Conformity Assessment
- Factory Surveillance
- Protection from Counterfeiting
- Education and Training

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Conformity Assessment

- Testing
- Determining Compliance
- Issuing a Attestation of Conformity
- Factory Inspection
- Market Surveillance
- Corrective Action

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Assuring Safety in a Competitive Market

- Development of Standards
- Conformity Assessment
- Protection from Counterfeiting
- Education and Training

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Trademark Counterfeiting

- 500 Billion Annually
- 5%-7% of Global Trade

Anti-Counterfeiting Main Objectives

- Protect Welfare and Safety of Consumers
- Protect Integrity of the UL Mark

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

UL Intellectual Property Training

- Train personnel at 40-50 US Customs ports every year
- Trained over 2500 law and code enforcement officials
- Annual average of over 100 US Customs seizures
- Retail values estimated at over $12 million

NDIA NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Course Agenda
Development of UL 508A
UL Product Categories
Supplement SB

Assuring Safety in a Competitive Market

- Development of Standards
- Conformity Assessment
- Protection from Counterfeiting
- Education and Training

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Assuring Quality and Sustainability in a Competitive Market

Applying Our Safety Model to the NDI Community

- Development of Standards
- Conformity Assessment
- Protection from Counterfeiting
- Education and Training

Assuring Quality and Sustainability in a Competitive Market

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

STRENGTH THROUGH INDUSTRY & TECHNOLOGY

Synthesis Panel Points From NDIA SE Division's DT&E Committee Co-Chairs

Tom Wissink

Lockheed Martin Fellow

John Lohse

Raytheon Engineering Fellow

Date: March 15, 2007

Some Opening Thought

- Bumper Stickers for Testers:
- Testers don't make the systems Warfighters use; Testers make those systems BETTER!
- Testing: You make it, We break it.
- A good Tester has the heart of a developer
- ...in a jar on their desk!
- *Pertempto ergo sum*
- I test, therefore I am

Key Observations & Comments

- Heard several times and agree that T&E (DT & OT) need to be involved earlier in SE process
  - DT&E Cmte plans to work this item in 2007
  - True for acquisition and implementation
- More Joint or Combined DT/OT
  - There needs to be specific guidance
- Sustainment needs to be designed into systems
- Need guidance on what “Sustainment Testing” could look like in CT/DT/OT timeframes
- Agree with need “More/Better SEs and PMs”
  - What about TEs (Test Engineers)

Other Learnings, Comments & Thoughts

- What are the Industry incentives that would ensure desired Sustainability and Suitability?
- Sustainability (or is that “Material Availability”) KPP: Deliver higher TRL with less performance at lower ownership cost
- Logistics & Maintainability Demos performed in controlled environment (like DT) with parts available
  - Needs to be more realistic
- Graduated Reliability during development
- There is a place for Standards – SOME should be updated and brought back into use
  - Tailored for Rapid Deployment, Major Acquisition, etc

A Final Thought

Many of these take Upfront Investment

- Fundamental change is needed

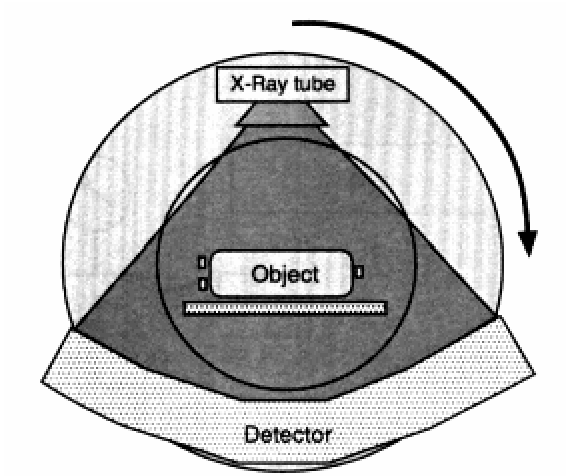
NEXT GENERATION EDS CT SYSTEMS

George L Zarur, PhD
Science Advisor
S&T DHS

Background & Current Systems

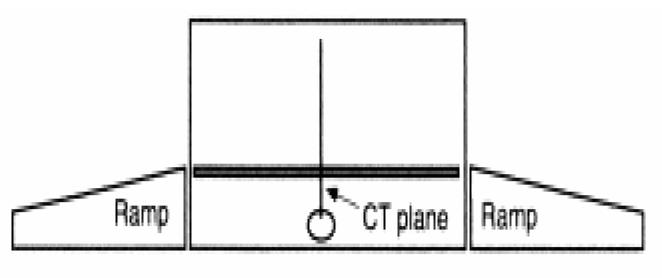
- Automated Explosives Detection Systems for Aviation prompted by Pan AM 103
- Design Genesis Medical CT

- An important Distinction:
- Aviation EDS CT has a significantly higher duty cycle. 400 bags per hour with newer systems 800 to 1000 bags per hour.

- Excellent Reference material
- National Academies Press 1998 (Configuration Management and Performance Verification of Explosives-Detection Systems)
- 

- Side view as a standalone System

- Optimal Configuration as an inline System with the Airport Baggage Handling System



- Limited Deployment in pre 911 plans
- Deployment by Airlines for limited screening

- Post 911 with passage Of ATSA Nov 19 2001, 100 percent screening of checked luggage

- Design dictated by the need for very high detection rates and 3 to 400 bags per hour throughput, speed of the rotating gantry, and the belt influenced the resolution and the size of the volumetric voxel under inspection

- Basic technology driven by Xray Source

- Detection based on density discrimination in a similar fashion to cancer detection. Unlike Medical CT, shape is never considered in detection.
- CT EDS systems are very effective at Detection and approaching optimal conditions.

RDT&E Efforts

- The testing and Certification Efforts at the Transportation Laboratory has developed a mature and effective process, that has resulted in a greater improvement in reliability and service levels with improved detection levels.

Next Gen EDS Drivers

- Overall Guiding Principle is based on Best Value and Affordability

- There is a significant data collected over the past few years on O&M costs
- Reduce Capital Acquisition Costs
- Installation Costs
- Field maintenance Costs

- False Alarm Rate Reduction has significant impact on operational costs, all alarms must be resolved and requires some sort of manual inspection, adding to labor and other system costs.

- A major distinction between Medical and Security systems can be traced to two factors.

- Passenger bags vary significantly both in size and content with huge clutter and many layers of material with varying densities and textures.

- Threats do not have unique density values and share the domain space with many harmless and innocuous substances

Next Generation Design goals

- Promotion of standards at various interfaces to reduce reliance on proprietary designs.

- Attempt to segregate the hardware from the Detection Algorithm, (not unlike implementation of the DNDO Advanced Spectroscopic Portal), Implement Image Standards, similar to medical CT

- Consideration of Non Rotating gantry designs with novel X-ray sources. Instead of a single source rotating at high speed, multiple sources, preliminary designs upward of 500 to 900 sources distributed in a circular fashion.
- Investigate the benefit of increased resolution through source characteristics and detector arrays.

- Investigate novel x-ray sources such as Nanotube technology with longer lifetime and lighter source assemblies and facilitate the use of dual energy for threat discrimination. Commercial units are likely end of CY07. Promise of significant lifetime and reduced costs, reduction in AC requirements.

- Investigate inclusion of add on Technologies which derive a chemical composition discrimanants, such as Coherent X-ray, where collected spectra relate to the individual chemical composition of a threat. Promising preliminary systems are in service.

Why Emphasis on False Alarm Reduction

- Although algorithm improvements have reduced the false alarm rates for current CT technology, rates exact an operational cost that can and should be reduced.
- Novel threats, such as Home made explosives and liquid explosives, often with a wide range of density and physical characterisitics, can lead to a significant increase in False Alarm rates

2007 versus 2001

- TSA has a mature and capable operation to collect and analyze operational data for a comprehensive life cycle cost management not available in late 2002 as CT EDS systems were deployed.
- Technology Advances in both material and Software with a larger pool of prospective developers with interest to compete for the Next Gen System Deployment.

Presentation by Mr. John Stoddart
23rd Annual National Test & Evaluation Conference
March 14, 2007

Sustainability KPP: Industry Weighs in on
Bidding for It and Building for It

GOOD MORNING AND THANK YOU FOR THAT KIND INTRODUCTION

I APPRECIATE THE INVITATION TO SPEAK TO YOU ABOUT THE SUSTAINABILITY KPP. MY MESSAGE IS PRETTY SIMPLE: INDUSTRY HAS THE WHEREWITHALL TO DESIGN AND BUILD AFFORDABLE SYSTEMS THAT CAN DRAMATICALLY IMPROVE SUSTAINABILITY AND REVOLUTIONIZE LOGISTICS.

WE, IN INDUSTRY, PROVIDE FOR SUPPORTABILITY OF THE SYSTEMS WE PRODUCE THROUGH A WIDE RANGE OF MEASURES, SUCH AS THOUGHTFUL DESIGNS, MANUALS, OPERATOR AND MAINTENANCE TRAINING, PROVISIONING FOR SPARE PARTS, AND CONTRACTOR LOGISTICS SUPPORT.

REGARDLESS OF HOW THE GOVERNMENT ASKS FOR SUSTAINABILITY, IT IS A NECESSARY ELEMENT OF ANY PROGRAM. BUT THE PROCESS OF ASSURING THAT SYSTEMS ARE SUSTAINABLE HAS NOT WORKED AS WELL AS IT COULD.

SYSTEMS THAT HAVE RELIABILITY PROBLEMS HAVE OBVIOUS IMPACTS ON WHETHER OUR SERVICE MEN AND WOMEN CAN MEET THEIR MISSION REQUIREMENTS.   BEYOND MISSION SUCCESS - <u>HIGH</u> RELIABILITY MEANS LESS INVESTED IN REPAIR PARTS, THE SUPPLY CHAIN THAT BRINGS THEM AND ULTIMATELY IN THE COST OF OWNERSHIP.

MAINTAINABILTIY PROBLEMS HAVE A MORE SUBTLE, BUT NONE-THE-LESS EXPENSIVE, IMPACT ON THE SERVICE AND ITS SUPPORT SYSTEM IN THAT REQUIRED MAINTENANCE MANHOURS CORRELATE DIRECTLY TO THE REQUIRMENT FOR MAINTENANCE PERSONNEL AND TECHNICAL SUPPORT. THE SIMPLER AND EASIER A SYSTEM IS TO MAINTAIN, THE FEWER MAINTAINERS THAT ARE REQUIRED.

DESPITE THE IMPACT ON MISSION PERFORMANCE AND OWNERSHIP COSTS, THE “ILITIES” OFTEN PLAY SECOND FIDDLE TO ATTRIBUTES DEEMED TO BE OF HIGHER PRIORITY BY THE GOVERNMENT, SUCH AS MOBILITY, LETHALITY, AND PROTECTION.

THE “TRADES” GENERALLY MADE AS REQUIREMENTS (INCLUDING KEY PERFORMANCE PARAMATERS, OR KPPS) ARE TRANSLATED INTO

PERFORMANCE SPECIFICATIONS, WHICH IN TURN, ARE TRANSLATED INTO CONTRACTUAL DELIVERABLES.

WHY TRADE THE "ILITIES"? USUALLY IT IS BECAUSE OF THE PRECEIVED IMPACT ON COST AND THE ABILITY TO ACHIEVE TESTABLE VERIFICATION THAT THESE REQUIRMENTS HAVE BEEN MET.

I BELIEVE THE DEFENSE INDUSTRY THAT I AM A PROUD MEMBER OF CAN MEET SUSTAINABILITY REQUIREMEMTS, BUT WE SHOULDN'T EXPECT JUST TO BE ABLE TO SAY "DEAR SANTA, I WANT IT ALL!" ACHIEVING SUSTAINABILITY PARAMETERS IS POSSIBLE, BUT IT WON'T BE FREE. EVEN WITH ALL THE TECHNOLOGICAL ADVANCEMENTS WE'VE MADE, THESE ARE STILL MACHINES – AND OUR MACHINES CAN BE COMPLEX, MAKING THE OPPORTUNITY TO HAVE FAILURES EQUALLY AS COMPLEX.

BUT FINDING WAYS TO DESIGN SUSTAINABILITY INTO SYSTEMS, FINDING WAYS TO MEASURE SUSTAINABILITY EFFECTIVELY AND FAIRLY AND REDUCING THE WARFIGHTER'S BURDEN IS WHAT WE ALL SHOULD BE ABOUT.

I OFFER TO YOU THAT INDUSTRY CAN DESIGN SYSTEMS THAT CAN BE SUSTAINED WITH LOWER BURDEN ON THE WARFIGHTER. CONSIDER THE FOLLOWING.

AT A RECENT CONFERENCE SIMILAR TO THIS ONE, A SPEAKER POSED A QUESTION TO THE ATTENDEES ABOUT MAKING PREPARATIONS FOR A TRIP IN THEIR CARS. IN THE PROCESS OF GETTING READY, HE ASKED IF THE ATTENDEES WOULD PACK A TOOL SET AND CARRY A SUPPLY OF SPARE PARTS.

FOR THAT MATTER, WOULD THEY, OR YOU, HAVE ANXIETY ABOUT WHETHER OR NOT THE CAR WOULD START WHEN THE KEY IS TURNED IN THE IGNITION, OR IF IT WOULD BREAK DOWN UNEXPECTEDLY? I THINK YOU WOULD AGREE THAT MOST OF US DO NOT GIVE SUCH MATTERS A SECOND THOUGHT BECAUSE COMMERCIAL AUTOMOBILES - AND TRUCKS FOR THAT MATTER - ARE QUITE RELIABLE. COMMERCIAL VEHICLES ARE RELIABLE BECAUSE OF THE COMPETITIVE MARKET PLACE AND BECAUSE WE, AS CONSUMERS, HAVE COME TO EXPECT AND DEMAND IT.

IN THE 1950S AND EARLY 1960S, AS CARS FROM JAPAN BEGAN TO GAIN A FOOTHOLD IN THE U.S. MARKET, THEY WERE NOT NOTICEABLY BETTER THAN DOMESTIC AUTOMOBILES. IN FACT, TO MANY THEY

SEEMED CHEAP, SMALL, AND RATHER ORDINARY COMPARED TO U.S. MODELS OF THAT ERA.

OVER TIME WE ALL WATCHED AS THE JAPANESE AUTO MAKERS MADE QUALITY AND RELIABILITY A PRIORITY AND WE HAVE SEEN THE IMPACT OF THEIR PHILOSOPHY IN REVERSALS OF MARKET POSITION AND EVEN THREATS TO LONG TERM SURVIVAL OF SOME FAMOUS U.S. BRANDS. BECAUSE OF COMPETITION, QUALITY OF U.S. CARS HAS GOTTEN BETTER, EVEN IF THE PERCEPTION HAS NOT CAUGHT UP.

WHAT DOES THIS HAVE TO DO WITH MILITARY VEHICLES AND MILITARY EQUIPMENT IN GENERAL? SOME IN INDUSTRY AND THE GOVERNMENT BOAST OF OPERATIONAL READINESS RATES FOR MILITARY SYSTEMS IN THE LOW 90s. IN SOME CASES, SYSTEMS' READINESS LEVELS MAY SIMPLY BE A FUNCTION OF AGE, OR HOW HARD IT IS BEING USED, OR EXTRAORDINARY MEASURES TO KEEP THEM UP. WELL, A 90-SOME PER CENT READINESS RATING MAY BE ACCEPTABLE - EVEN A CAUSE FOR EUPHORIA - FOR MILITARY EQUIPMENT IN A THEATER OF OPERATIONS; HOWEVER, YOU WOULD NOT ACCEPT 90 PER CENT FOR YOUR LEXUS, CAMRY, OR FORD. YOU FULLY EXPECT 99.999 PER CENT! THAT IS WHY YOU DON'T BOTHER TO PACK THE TOOL CHEST AND SPARE PARTS, OR WORRY ABOUT NOT STARTING OR BREAKING DOWN AT THE LEAST OPPORTUNE MOMENT.

FOR US, BREAKING DOWN WOULD BE AN INCONVENIENCE THAT MIGHT SHAPE YOUR NEXT CAR PURCHASE DECISION. BUT BREAKING DOWN FOR PEOPLE IN COMBAT IS THE DIFFERENCE BETWEEN LIFE AND DEATH. SYSTEMS THAT FAIL TOO FREQUENTLY ARE HARD TO SUSTAIN, DRAINING COMBAT POWER AND CAUSING A RIPPLE EFFECT THROUGHOUT THE FORCE.

WHAT ELSE IS DIFFERENT BETWEEN YOUR CAR AND MILITARY EQUIPMENT? YOU DON'T CHECK UNDER THE HOOD BEFORE YOU OPERATE YOUR CAR. YOU DON'T GO THROUGH A PREVENTATIVE MAINTENANCE CHECKLIST. NO, ASSUMING YOU HAVE KEPT PACE WITH TECHNOLOGY, INSTEAD A COMPUTER CHECKS THE VITAL SYSTEMS IN YOUR CAR AND TELLS YOU IF THE BRAKES PADS ARE WORN, LIGHTS ARE INOPERABLE, FLUIDS ARE LOW, OR IF THERE IS A PROBLEM WITH THE ENGINE. IF THERE IS A PROBLEM, THE COMPUTER TELLS THE MECHANIC WHAT IS WRONG FOR MOST OF THE VEHICLE'S CRITICAL SYSTEMS. SOME CARS CAN COMMUNICATE WITH THE MANUFACTURER AND SEND YOU A REMINDER OF AN UPCOMING SERVICE OR WITH AN EMERGENCY SERVICE IF YOU ARE IN AN ACCIDENT OR LOST.

THE MILITARY HAS BEEN TRYING TO HEAD IN THE SAME DIRECTION FOR SOME TIME NOW. THE REASON THERE HASN'T BEEN MORE PROGRESS

IS NOT BECAUSE INDUSTRY CANNOT DO IT, OR BECAUSE MILITARY SYSTEMS ARE UNIQUE, OR BECAUSE SUCH FEATURES ARE UNAFFORDABLE BELLS AND WHISTLES. WHEN JAPANESE CAR MAKERS WERE BEGINNING TO BUILD THEIR HIGHLY RELIABLE REPUTATIONS AS COMPARED TO U.S. (AND EVEN EUROPEAN) BRANDS, WAS THERE A BIG DIFFERENCE IN THE SELLING PRICES OF MORE RELIABLE CARS AS OPPOSED TO LESS RELIABLE ONES? NO. THE JAPANESE WERE ABLE TO DESIGN FOR GREATER RELIABILITY AND SUSTAINABILITY WHILE REMAINING PRICE COMPETITIVE BECAUSE THEY HAD TO IN ORDER TO MEET THE DEMANDS OF THEIR CUSTOMERS AND GAIN AN ADVANTAGE.

BUT PRICE COMPETITIVENESS IS WHERE MOST OF US IN INDUSTRY LIVE AND IF <u>OUR</u> CUSTOMER IS WILLING TO LET SUSTAINABILTIY BE A “NICE TO HAVE” RATHER THAN A “MUST HAVE,” THEN NONE OF US CAN AFFORD TO TAKE THE RISK THAT WE’LL HAVE OVER BUILT THE REQUIREMENT AND PRICED OURSELVES OUT OF THE COMPETITIVE RANGE.

THERE ARE BRIGHT SPOTS IN THE SUSTAINABILITY FUTURE – FOR EXAMPLE, IN THEIR LOGISTICS SUPPORT VEHICLE REPLACEMENT, OR LVSR, THE MARINES WANTED TO SIMPLIFY LOGISTICS SUPPORT SO THEY IMPOSED A REQUIREMENT FOR A SINGLE LUBRICANT FOR THE ENGINE AND TRANSMISSION AND A SINGLE RESEVOIR.

WE AT OSHKOSH WERE SUCCESSFUL IN PUTTING THAT FEATURE IN THE DESIGN AS PART OF A BROAD PLAN TO IMPROVE SUSTAINABILITY.

HYBRID ELECTRICS AND ONBOARD POWER GENERATION CAPABILTIES ARE GENERATING MOMENTUM AND THESE CAPABILITIES HAVE THE POTENTIAL TO MAKE VEHICLES SIMPLER AND MORE SUSTAINABLE. HYBRID ELECTRIC TECHNOLOGY CAN REDUCE FUEL CONSUMPTION, AND DUE TO ITS ABILITY TO PRODUCE EXPORTABLE MILITARY GRADE ELECTRICAL POWER, IT ALSO COULD REDUCE THE REQUIEMENT FOR TRAILERS AND POWER GENERATORS. THIS, IN TURN, MEANS FEWER SYSTEMS WOULD HAVE TO BE SUSTAINED.

THERE IS ANOTHER HUGE OPPORTUNITY ON THE TABLE RIGHT NOW IN THE JOINT LIGHT TACHTICAL VEHICLE.   AS THE USER COMMUNITIES STRUGGLE TO BALANCE JLTV’S THREE MOST IMPORTANT ATTRIBUTES: PERFORMANCE, PROTECTION, AND PAYLOAD, WHERE WILL RELIABLITY AND MAINTAINABILITY FALL AMONG PRIORITIES FOR A FLEET THAT WILL BE POTENTIALLY THE HIGHEST DENSITY MOBILITY SYSTEM IN EITHER THE ARMY OR THE MARINE CORPS?   I CONTEND THAT IMPROVED SUSTAINABILITY CAN BE PROVIDED WITHOUT HAVING TO TRADE MISSION CAPABILITIES.

FROM MY PERSPECTIVE, WE CAN DO BETTER. WE CAN DO BETTER AND IT DOES NOT NECESSARILY MEAN THAT COSTS WILL SUDDENLY MAKE SYSTEMS UNAFFORDABLE. WE CAN DESIGN VEHICLES THAT ARE MODULAR, SO COMPONENTS CAN BE SWAPPED OUT IF THEY BECOME INOPERABLE, BATTLE DAMAGED, OR IF NEWER TECHNOLOGY COMES ALONG. THEY CAN BE INHERENTLY MORE RELIABLE AND MORE EASILY REPAIRABLE BY ASSURING EASIER ACCESS TO ALL ASSEMBLIES, LEADING TO IMPROVEMENTS IN SUSTAINABILITY. THEY CAN TELL THE OPERATOR WHEN SOMETHING HAS FAILED (OR IS ABOUT TO FAIL), THE STATUS AND LOCATION OF THE SYSTEM, AND MORE. IN OTHER WORDS, THEY CAN BECOME SOMETHING MORE LIKE YOUR TRUSTWORTHY CAR.

WE JUST NEED OUR CUSTOMER TO REQUIRE IT FROM US AND WE NEED TO KNOW HOW WE WILL BE FAIRLY EVALUATED. THEN WE CAN DESIGN EQUIPMENT THAT IS DESIGNED ACCORDINGLY FROM THE GROUND UP. IF WE CAN DO THIS, THE IMPLICATIONS ARE HUGE.

CONSIDER THAT LOGISTICS IS LARGEST PART OF THE FORCE … SOME 70% IN THE CASE OF THE ARMY. THE STRUCTURE DEVOTED TO LOGISTICS IS DIRECTLY RELATED TO THE AMOUNT OF FUEL, WATER, AMMUNITION, SPARE PARTS AND OTHER SUPPORT ITEMS NEEDED. AND, ALL OF THAT REQUIRES TRANSPORTATION OPERATORS THAT

NEED TO BE TRAINED, EQUIPPED, SUSTAINED, PROTECTED, AND PROVIDED HEALTH CARE, AND SO ON.

FOR EVERY REDUCTION IN DEMAND THAT WE CAN DESIGN INTO THE POINTY END OF THE SPEAR, WE CAN DRAMATICALLY REDUCE THE LOGISTICS BURDEN AND MAKE THE FORCE MORE SUSTAINABLE.

AT THE END OF THE DAY WE WILL BID, BUILD AND DELIVER WHAT THE GOVERNMENT ASKS OF US. SUSTAINABILITY IS ACHIEVABLE – AND IT CAN BE A KPP, BUT A GREAT DEAL OF THOUGHT WILL HAVE TO GO INTO THE MEASURES OF SUCCESS AND THE PARAMETERS FOR TESTING IF SUSTAINABILITY IS NO LONGER “TRADE SPACE” AND MUST BE MET AS A CRITERION TO GO FORWARD WITH A PROGRAM.

AND MOST OF ALL – EVEN THOUGH SUSTAINABILITY SHOULD BE AFFORDABLE – WE ARE GOING TO HAVE TO DO A BIT MORE THAN SAY “DEAR SANTA I WANT IT ALL.”

THANK YOU FOR YOUR ATTENTION AND I LOOK FORWARD TO YOUR QUESTIONS AND A LIVELY DISCUSSION!